Sky and TELESCOPE

Springfield's Foucault pendulum

★

Vol. XIX, No. 3

JANUARY, 1960

50 cents

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In This Issue:

How Can We Detect Radio Transmissions from Distant Planetary Systems?

A Foucault Pendulum

The Practical Use of Ephemeris Time

Variable Stars in the Orion Nebula

McCrea's Theory of the Solar System's Origin

Graphic Time Table of the Heavens — 1960

TEACHING WITH A FECKER 15″ CASSEGRAIN

COMMENTS BY
DR. N. E. WAGMAN

Director, Allegheny Observatory of the University of Pittsburgh

"This telescope, with its accessories, provides just about everything that can be desired for use in a program of instruction in astronomy.

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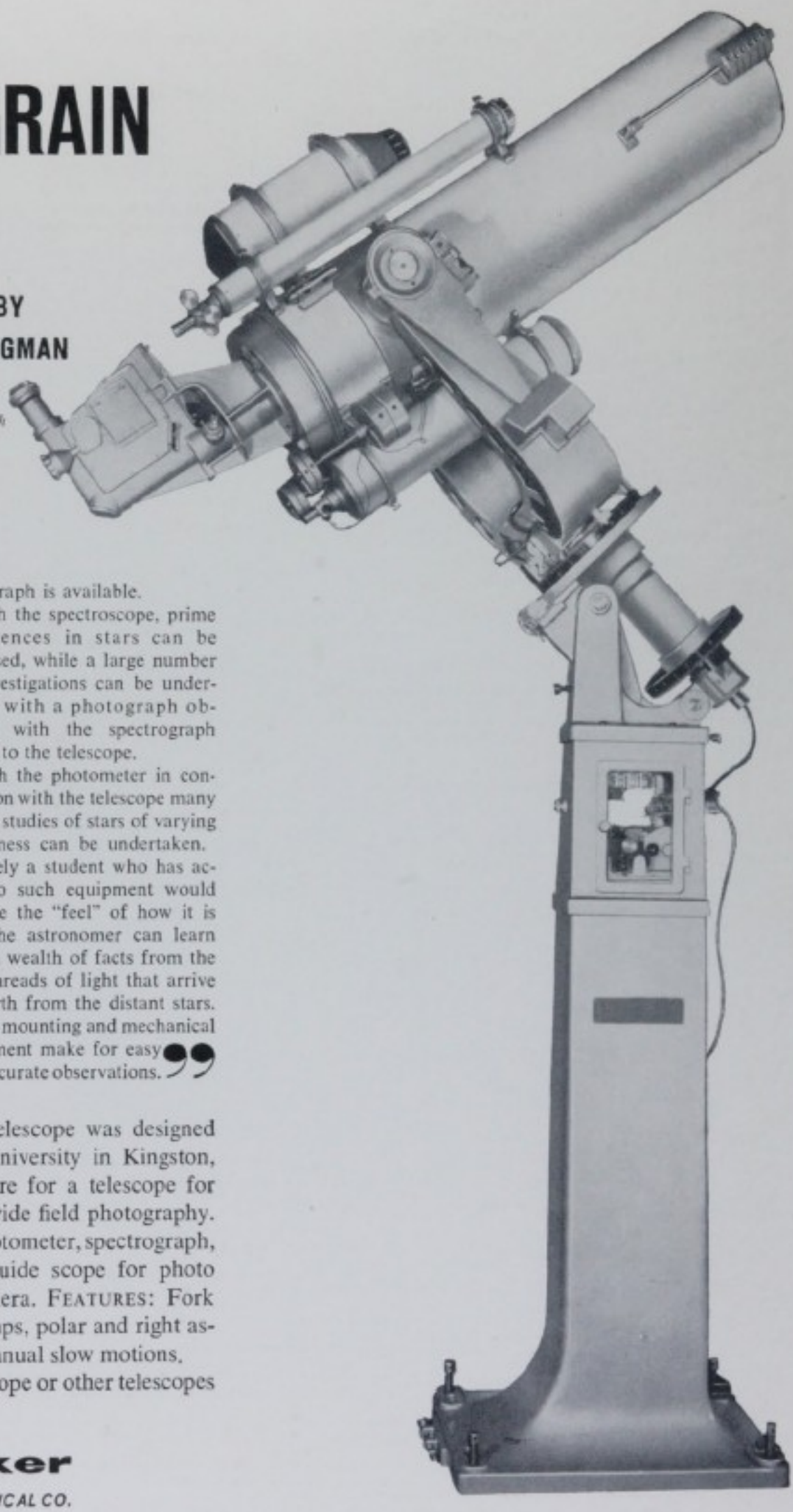
The mounting and mechanical equipment make for easy and accurate observations."



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Sky and TELESCOPE

CHARLES A. FEDERER, JR., *Editor*
JOSEPH ASHBROOK, *Technical Editor*

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Vol. XIX, No. 3 JANUARY, 1960

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COVER: A class of school children watches the swinging bob of the Foucault pendulum in the Museum of Science at Springfield, Massachusetts, where the earth's rotation causes a deviation of 10 degrees an hour in the apparent direction of the pendulum's swing. This device was designed and built by the Springfield Stars Club, supported by donations of material and time from local businessmen. T. J. Morehead Studios photograph. (See page 144.)

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LETTERS

Sir:

Although Bifrost Observatory here in Sweden is my own property, a few amateurs and I are trying to develop it into another Stellafane, that is, an observing and meeting place for active amateur astronomers and telescope makers. There is at present no such place that I know of in Scandinavia.

The observatory is well equipped. Among the instruments already in operation, or soon to be, are two 6-inch f/10 reflectors, one 6¾-inch f/6 reflector, two 4-inch refractors, a 4-inch off-axis reflector, and a 4½-inch Schmidt camera. There is also the 135-mm. f/4.5 camera that was used in my photographic atlas of the sky described on page 479 of the August, 1957, SKY AND TELESCOPE.

The main telescope will be a 16-inch reflector now under construction. It will be used for photography, photoelectric photometry, and spectroscopy, at its primary, Newtonian, and semi-Cassegrainian foci, respectively.

Our 4½-inch Schmidt camera was constructed with hand tools only, and has a number of features of interest to amateurs. It can be equipped with an objective prism for taking stellar spectra, and its focal surface is flat instead of curved, a field-flattening lens of Vaisala's design being mounted just in front of the focus. The entire plateholder and lens assembly is supported in the center of the tube by four pairs of piano wires, which offer little obstruction to the passage of light and permit easy centering of the plate itself.

In order to defray part of our costs in developing a Scandinavian Stellafane, Bernth Malm and I have prepared two large detailed drawings of the Schmidt-camera layout and body construction, together with four pages of explanatory matter (in English). Interested amateurs who wish to obtain these plans should send the undersigned $1.50 from the United States or $1.30 from Canada.

Our observatory's name, *Bifrost,* means the trembling or undulating bridge, that is, the Milky Way or the rainbow over which Viking champions were entitled to ride into Valhalla.

RUNE FOGELQUIST
Bösslinge, Börje
Uppsala, Sweden

Sky and Telescope Binder

This dark blue fabrikoid binder, for holding 12 issues of the magazine, is priced at $3.50 each, postpaid in the United States; $4.00 in Canada. Your name can be gold-stamped for 70¢ extra, the volume number for 40¢, both for a dollar; print desired lettering clearly. Payment must accompany order. (Sorry, but no foreign orders accepted.)

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In this three-dimensional model by Sarah Lippincott, all known stars within 16 light-years of the sun (center) are shown as if they were being viewed from the direction of the vernal equinox. The triple star Alpha Centauri appears below and to the left of the sun; Altair is the large object at the extreme left; and Sirius is the largest in the right half of the model. Photograph courtesy Sproul Observatory, Swarthmore College.

How Can We Detect Radio Transmissions from Distant Planetary Systems?

FRANK D. DRAKE

*National Radio Astronomy Observatory**

THE QUESTION of whether there is intelligent life elsewhere in the universe, outside the bounds of the solar system, has long been fascinating, but apparently unanswerable. Optical telescopes offer no help with the problem. It would require a very large telescope outside the earth's atmosphere, say on the moon, merely to detect the existence of planets accompanying the closest stars. The presence of intelligent life would still be unrecognizable.

Could a radio telescope detect intelligent radio transmissions over interstellar distances? It is easy to show that the distance R over which a signal can be observed is given under most conditions by the accompanying formula. To see what ranges are obtainable with available equipment, let us consider an attempt by the 85-foot radio telescope of the National Radio Astronomy Observatory to detect a high-power radar signal.

Such a signal might be like that radiated by the Millstone Hill radar antenna at Westford, Massachusetts, when it achieved radar echoes from Venus (SKY AND TELESCOPE, May, 1959, page 384). At such times, the Millstone radar has roughly an effective radiating power (P_e) of 10^{15} watts and a band-width (B) of 10 cycles per second. The 85-foot has an effective receiving area (A) of 370 square meters and, if we are using a maser, T might be only 10° Kelvin and t about 100 seconds.

Using these values in the formula, we find that the radar transmission would be detectable even if it originated 8.7 light-years away! This is as far as Sirius, and about twice as far as Alpha Centauri. Because of our large antennas and new sensitive receivers, we are already capable of detecting the radio transmissions of intelligent beings over interstellar distances.

When the receiving antenna is a parabolic reflector, this rule-of-thumb formula may be applied: The distance in light-years at which strong present-day transmitters can be detected is about equal to the diameter of the antenna in feet divided by 10. Thus the U. S. Navy's 600-foot antenna, now under construction at Sugar Grove, West Virginia, could detect intelligent life transmissions from as far away as 60 light-years, while the Cornell University 1,000-foot bowl in Puerto Rico and NRAO's proposed 1,000-foot antenna will be able to see about 100 light-years. Within that distance of the earth, there are something like 10,000 stars.

It is very difficult to estimate how many of those stars may be supporting civilizations as advanced as ours. For many years, it was felt that the formation of the solar system was the result of a chance collision between two stars, or some other unlikely event. Furthermore, the development of life on planets was thought to be a very rare occurrence. This led to a pessimistic picture of the abundance of life in the galaxy.

In recent times, however, it has become clear that the formation of a second body or bodies is an essential part of the formation of a star. It is possible that most stars, not members of binary or multiple systems, are accompanied by families of planets or meteorites. As explained by Otto Struve in his article on page 154 of this issue, probably at least a few per cent of all stars are accompanied by planets.

How many of these planets might have intelligent life? The pioneering experiments of Stanley Miller at the University of Chicago, as well as later studies, have shown that complicated organic molecules could well have been formed in great quantities during the early history of the earth or any similar planet. These molecules, which are the basic building blocks of life, should provide for its emergence on other planets just as they apparently did on earth.

We might expect life to be quite common on planets, then. However, recent papers by K. Kordylewski in Poland and Su-Shu Huang in the United States consider anew the fact that life will thrive only on planets that are at such distances from their star that the temperature is appropriate. This factor limits intelligent life to just a few planets in each planetary system, including our own. And the star must be long-lived, not changing its brightness appreciably dur-

DISTANCE OF DETECTION OF COSMIC RADIO SIGNALS

$$R = 8 \times 10^{-6} (P_e A/T)^{1/2} (t/B)^{1/4} \text{ light-years}$$

R is the distance over which the signal can be observed;

P_e is the effective radiated power of the transmitter, in the direction of the earth, expressed in watts;

A is the effective area of the receiving antenna, in square meters;

T is the excess receiver noise temperature of the receiver used, in degrees Kelvin;

t is the receiver averaging time, in seconds;

B is the accepted band-width of the signal (that is, the band-width of the receiver used) in cycles per second.

For detailed explanations of the terms used in this formula and other information about radio receivers useful in the present discussion, refer to Dr. Drake's article in the November and December, 1959, issues, pages 26 and 87, respectively. — ED.

*Operated by the Associated Universities, Inc., under contract with the National Science Foundation.

ing the billions of years that are required for the evolution of intelligent beings from a collection of organic molecules. The over-all result is to limit such life to planets of main-sequence stars of spectral types *F*, *G*, *K*, and possibly *M*. However, this still includes about half of all the stars.

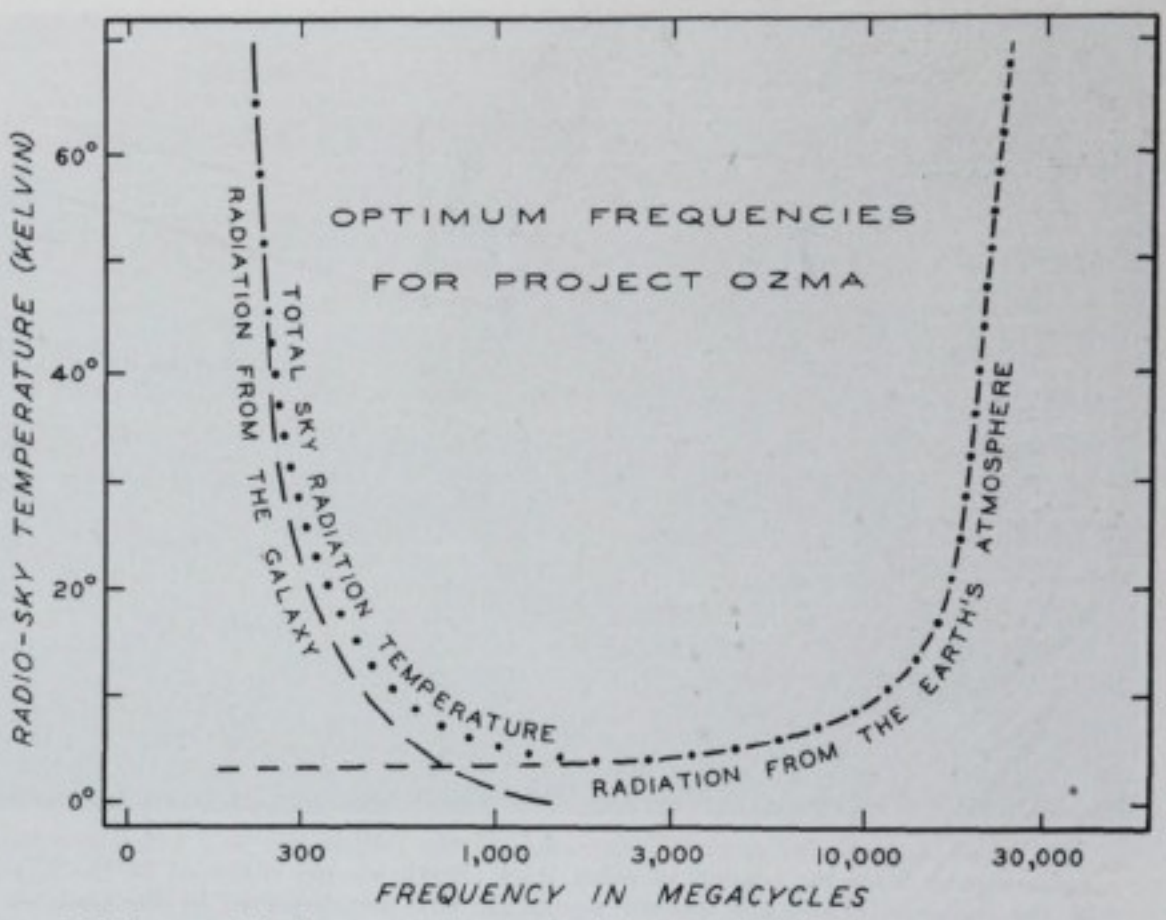
The stars have quite varied ages. This, plus the good probability that biological evolution occurs at unequal rates on different planets, means that the present level of evolutionary development may be quite different from planet to planet. The age of the sun appears to be average. Thus, it is likely that throughout the galaxy there are scattered civilizations more advanced, at the same level, and less developed than ours.

From all the considerations above, it appears that strong intelligent radio transmissions may emanate from the vicinities of, at best, 25 per cent of the stars and, at worst, perhaps one star in a million, which is the extremely conservative estimate recently suggested by Harlow Shapley in his book, *Of Stars and Men*. Obviously, these estimates are not very helpful, except in one respect: They make the possibility good that at least one of the 10,000 stars soon to be within our reach has a civilization using radio techniques. It is, then, worth while to apply our newly found technical prowess in an effort to detect interstellar radio transmission.

What search frequency would be best? Consider what might be called the principle of technical perfection. It is only about 50 years since radio communication was invented, yet we have already very nearly achieved technically perfect instruments, and within 50 more years we should have them. By *technical perfection* we mean that the limits on communication-system sensitivities are not set by deficiencies in the apparatus, such as receiver noise, but by natural phenomena over which man has no control. This is a state in which further improvements in apparatus will not improve the operational results.

A century is only about a hundred-millionth of the age of our galaxy. Thus, on the galactic time scale, a civilization passes abruptly from a state of no radio ability to one of perfect radio ability. If we could examine a large number of life-bearing planets, we might expect to find in virtually every case either complete ignorance of radio techniques, or complete mastery. This is the principle of technical perfection. Our civilization may be one of an extremely small minority in transition between the two possible states — this, in fact, may be the only major feature in which man is unique.

Therefore, it may be logical to assume that the civilizations we might detect possess complete mastery of radio already. The transmissions we seek will obviously be very powerful ones, in which large information transfer over long distances is being attempted. Frequencies will be chosen for which the natural limitations on performance are least. Two of these limitations are important: galactic radio noise emission, and noise from the planetary atmosphere, if reception from beneath the atmosphere is being attempted.



Only in a relatively narrow range of radio frequencies is there a reasonable chance of receiving transmissions from extraterrestrial beings. At low frequencies such signals would be smothered by radio noise of galactic origin; at high frequencies, radiation from the earth's atmosphere would overwhelm them. Both these types of interference are charted here, together with their resultant, the total sky radiation temperature. NRAO graph.

Both these emissions insert noise into the receiver, and have the same effect as though the receiver itself were noisy. The graph shows for the earth the radio-sky temperature produced by each of these sources of noise, and their combined effect. This last would be the excess receiver noise temperature of an otherwise perfect receiver. Obviously, the best frequencies to use for our search are those where this total sky temperature is least.

For instance, from beneath the atmosphere of a planet like the earth, the band from 1,000 to 10,000 megacycles per second would be the optimum for reception of long-range transmissions. If, however, reception is being done from above the atmosphere, as the principle of technical perfection and our own success with satellites suggest, frequencies above 10,000 megacycles are also good candidates.

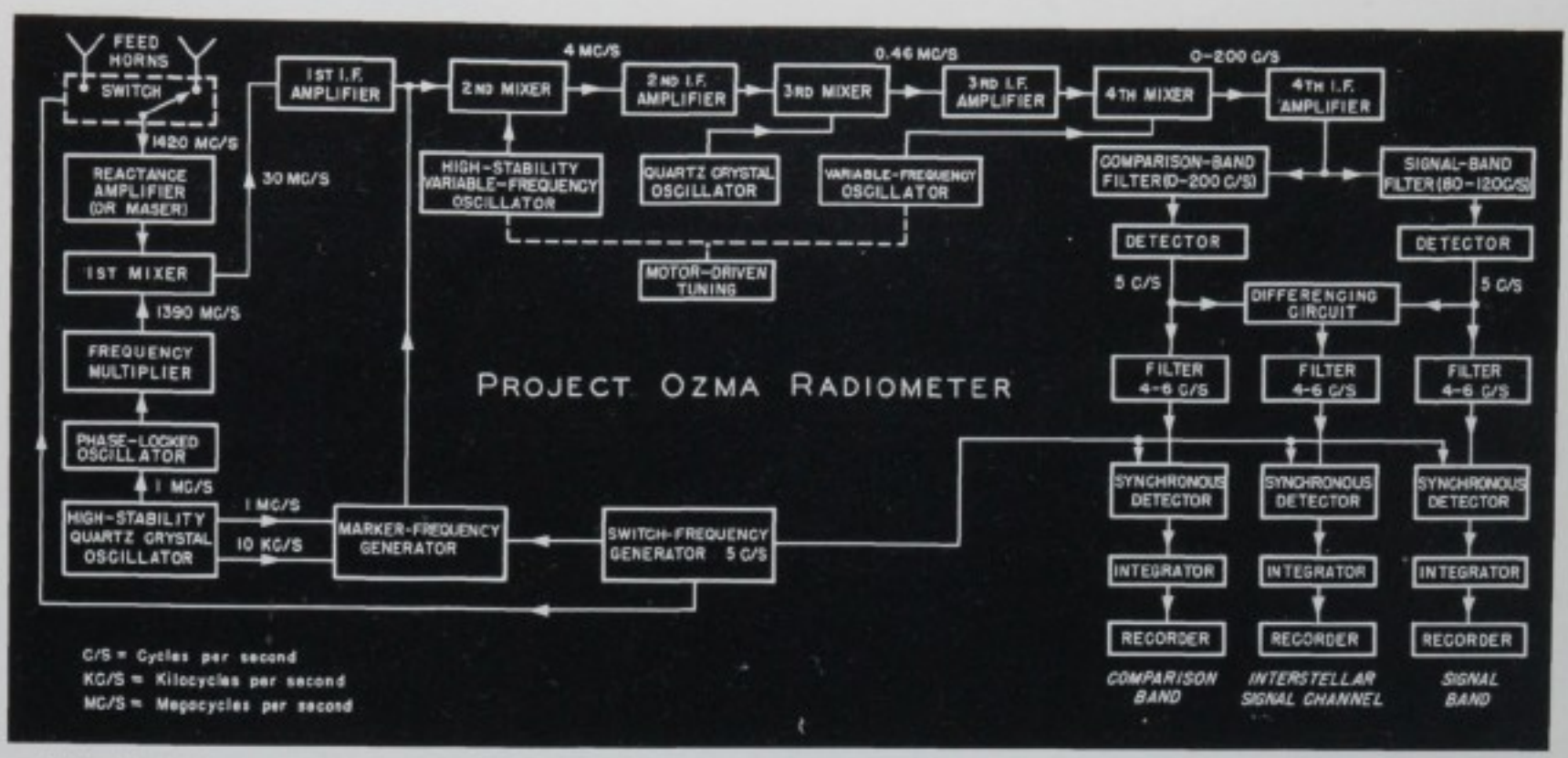
Guiseppi Cocconi and Philip Morrison, of Cornell University, have gone one step further in a paper that appeared in the British journal *Nature* (September 19, 1959, page 844). They speculate that civilizations in space may have produced strong radio beams directed toward their nearby neighbors, in an effort to establish two-way radio communication at the earliest possible time. Such an attempt would use the frequency at which high-sensitivity, narrow-band radio telescopes would be first operated extensively during radio development of civilizations in the Milky Way. Throughout the galaxy it could very well be 1,420 megacycles, the frequency of the 21-centimeter interstellar hydrogen line.

All these considerations suggest confining our search to the band between 1,000 and 10,000 megacycles, and that possibly frequencies around 1,420 megacycles offer the best chance for success.

What will be the characteristics of the sought-after signals? Communication theory states that the narrower the band-width of a transmitted signal of fixed total power, the greater the range of successful transmission. Since we are attempting, in any case, to intercept transmissions of great power, where great range is presumably the goal, we can expect the signals to be of narrow band-width. This is advantageous, as it will allow us to distinguish the signals from naturally occurring cosmic noise, which is extremely broad in band-width.

We should expect an appreciable Doppler shift in the transmitted frequency over short periods, because of the likelihood that the transmitter will be in orbital motion around a star or planet. This shift will help us distinguish signals from cosmic noise and from terrestrial interference. The signal strength may vary with time, if coded information is being sent, and also possibly due to the changing orientation of the earth with respect to the transmitter. Finally, the transmission should come from the direction of a nearby star.

Summarizing this discussion, a receiver designed to detect interstellar radio sig-



This block diagram indicates the operation of the radiometer now being completed for Project Ozma, to detect possible radio signals from the planets of other stars. Radio energy collected by the 85-foot antenna enters the feed horns shown at the upper left, and the desired signals, if any, are displayed by the recorder of the interstellar signal channel, lower right. In practice, the second mixer also functions as the second intermediate-frequency amplifier. NRAO diagram.

nals at the surface of the earth should:

1. Operate at a frequency above 1,000 megacycles, with performance near 1,420 desirable.

2. Operate over a considerable range of band-widths, including 10 cycles per second and less.

3. Have receiver frequency vary considerably less than the band-width during the averaging time of the receiver, specifically not more than about one cycle per second in several minutes.

4. Have the most sensitive system now available.

5. Eliminate receiver noise effects as much as possible.

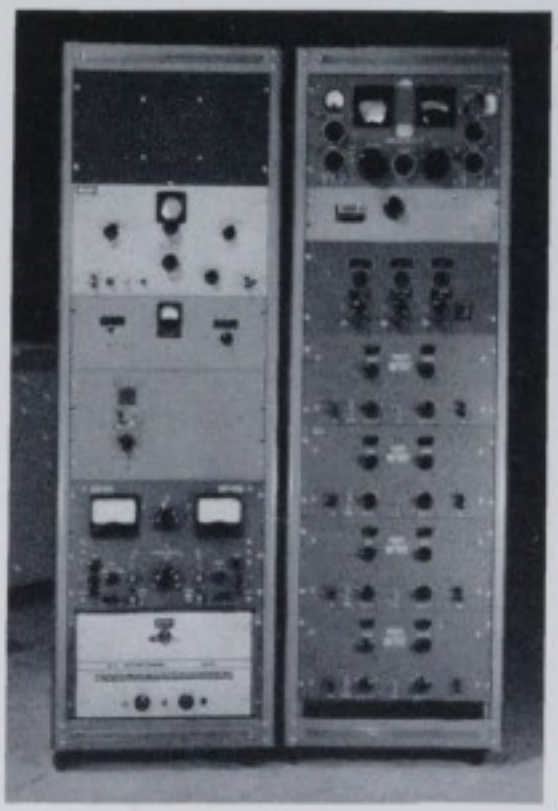
6. Discriminate against broad-band cosmic noise, if possible.

7. Preferably reject terrestrial interference that resembles the sought-after signal.

In an effort to detect interstellar radio transmissions, NRAO has established Project Ozma. It is named for the queen of the imaginary land of Oz – a place very far away, difficult to reach, and populated by exotic beings. A radiometer that fulfills the specifications above is now in the final stages of construction, a portion of it being shown in the picture. Almost all of the assembly and testing to date have been carried on by W. Waltman, Purdue University, and R. W. Meadows, of the United Kingdom's Department of Scientific and Industrial Research.

A block diagram is given here of the Ozma radiometer, which operates near 1,420 megacycles. It is essentially a highly stable narrow-band superheterodyne receiver, which utilizes the principles of both the Dicke radiometer and the d.c.-comparison type. (See November, 1959, pages 26-28.)

Two horns are placed together at the focus of the parabolic antenna, in order to eliminate terrestrial interference to some extent. These horns give the antenna two beams, one to point at the star under study, the other off into space near the star. As the electronic switch connects first one horn and then the other to the receiver, the telescope will look alternately at the star and at the sky beside it. Any radiation from the star will then enter in pulses whose duration is controlled by the switch. The synchronous detectors near the output end of the circuit will respond only to pulses synchronized with the switch, thus detecting only the desired signal. Receiver noise is eliminated, and also terrestrial disturbances.



These cabinets contain those portions of the Ozma radiometer that are located in the control building of the radio telescope. Not shown are the feed horns, reactance amplifier, switch, first local oscillator system, and first intermediate-frequency oscillator.

Interference generally enters a radio telescope antenna through the horns directly, without a reflection from the paraboloid. In that case, both horns should receive the interfering signal with the same strength, and when the switch changes from one horn to the other there will be no change of level in the interference entering the receiver. As a result, the interference signal is not pulsed, and the synchronous detectors ignore it.

In the present receiver, immediately after the switch there comes a reactance amplifier, to be replaced later with a maser. The amplifier, which gives the radiometer high sensitivity, was built by Ewen-Knight Corp., while the electronic switch was made by H. Hvatum of NRAO.

The signal then undergoes four frequency conversions, this many being necessary because the final intermediate frequencies are very low, due to the narrow-band-width requirements. The frequency received by the radiometer is directly dependent on the frequencies of the four oscillators, whose output signals beat with the true signal to produce the intermediate frequencies. In our specifications all four oscillators must hold their frequencies constant to better than one cycle per second in 100 seconds, if the over-all received frequency is also to be that constant.

This is a most difficult requirement for the first oscillator, because its final frequency is about 1,390 megacycles, and it therefore must remain constant to one part in a billion. This accuracy is achieved by means of a special quartz crystal oscil-

lator, the crystal being kept at a very constant temperature in an oven within an oven. The output of this oscillator is multiplied in frequency to give the desired final frequency.

A marker-frequency generator is used to provide weak signals from the output of the very stable oscillator at many fixed frequencies. These signals are inserted into the receiver for determining the exact frequency on which the receiver is operating, allowing the detection of Doppler effect.

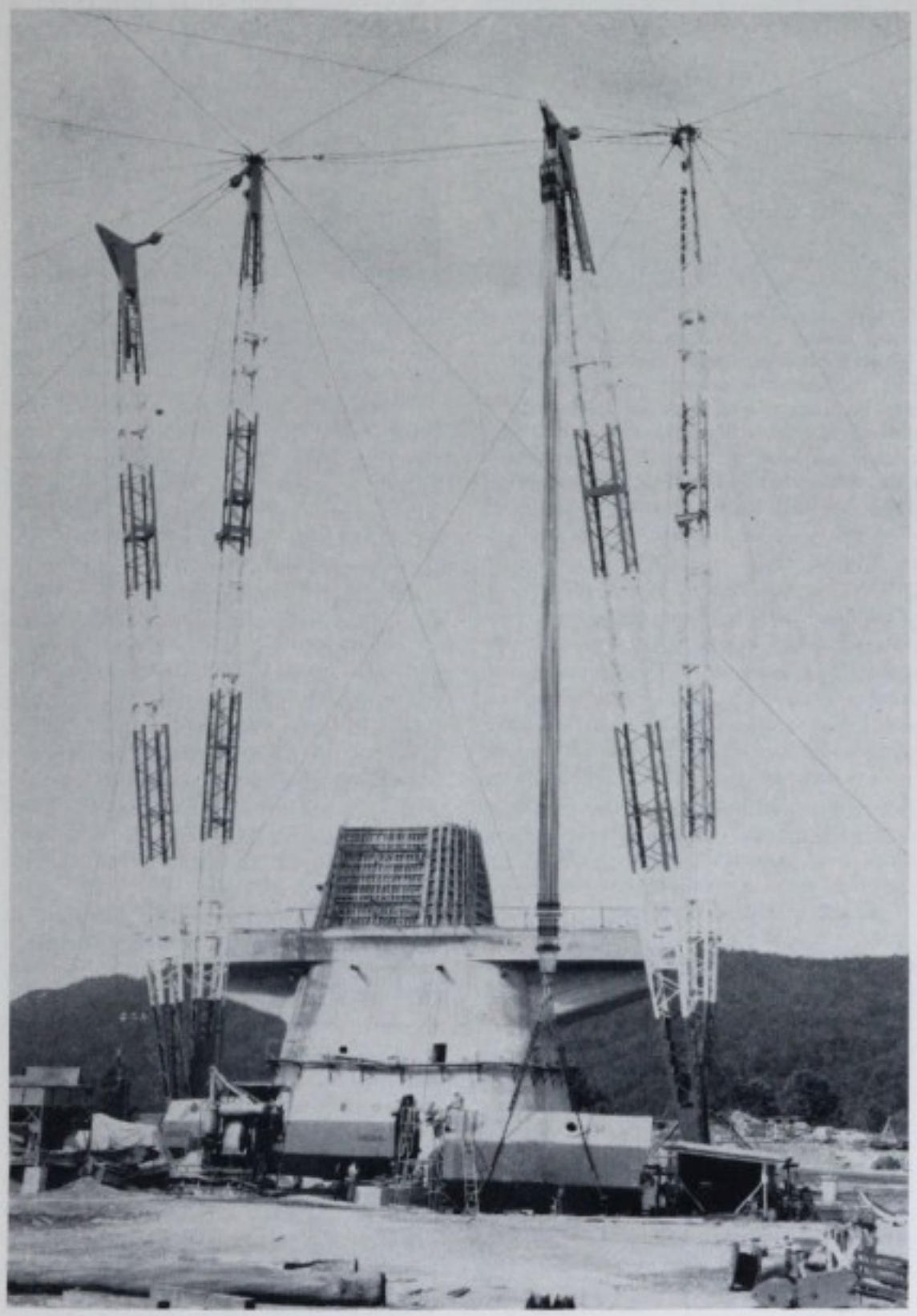
After the fourth intermediate-frequency amplification, two filters pick out a broad band of noise, called the *comparison band*, and a narrow one designated the *signal band*. The gain of these filters is adjusted so that when very broad-band noise enters them their total outputs are equal. When these outputs are passed into the differencing circuit, its output is zero. However, a narrow-band signal fills only some of the frequencies of the filter for the comparison band, but all of those in the signal-band filter. The output of the narrow-band filter is then greater than that of the broad-band one, and there is a net output from the differencing circuit. This use of the d.c.-comparison circuit makes the radiometer respond only to narrow-band signals. As drawn here, the radiometer is set up for signals of about 40-cycles-per-second band-width. In the actual receiver, the electronic filters have variable band-widths that may be quickly adjusted to desired values.

The filters placed before the synchronous detectors pass only the frequencies to which the detectors will respond, and reject other frequencies that might cause them to operate improperly.

We see that an output from the final synchronous detector will occur only when receiving a narrow-band signal from a direction in which one of the antenna beams is pointing – the desired interstellar signal. The integrator only averages the signal strength over a chosen interval. The other two synchronous detectors and integrators connected directly to the comparison-band and signal-band channels monitor the performance of the radiometer.

Barring serious technical difficulties, our radiometer will go into operation on the 85-foot antenna early this year. The first objects to be looked at are Tau Ceti and Epsilon Eridani, two solar-type stars about 11 light-years away. Unidentified radio sources whose celestial positions are close to those of nearby stars will also be studied at an early opportunity.

It appears probable that this project or a similar one will someday succeed in detecting an artificial signal. Needless to say, the scientific and philosophical implications of such a discovery will be extremely great.



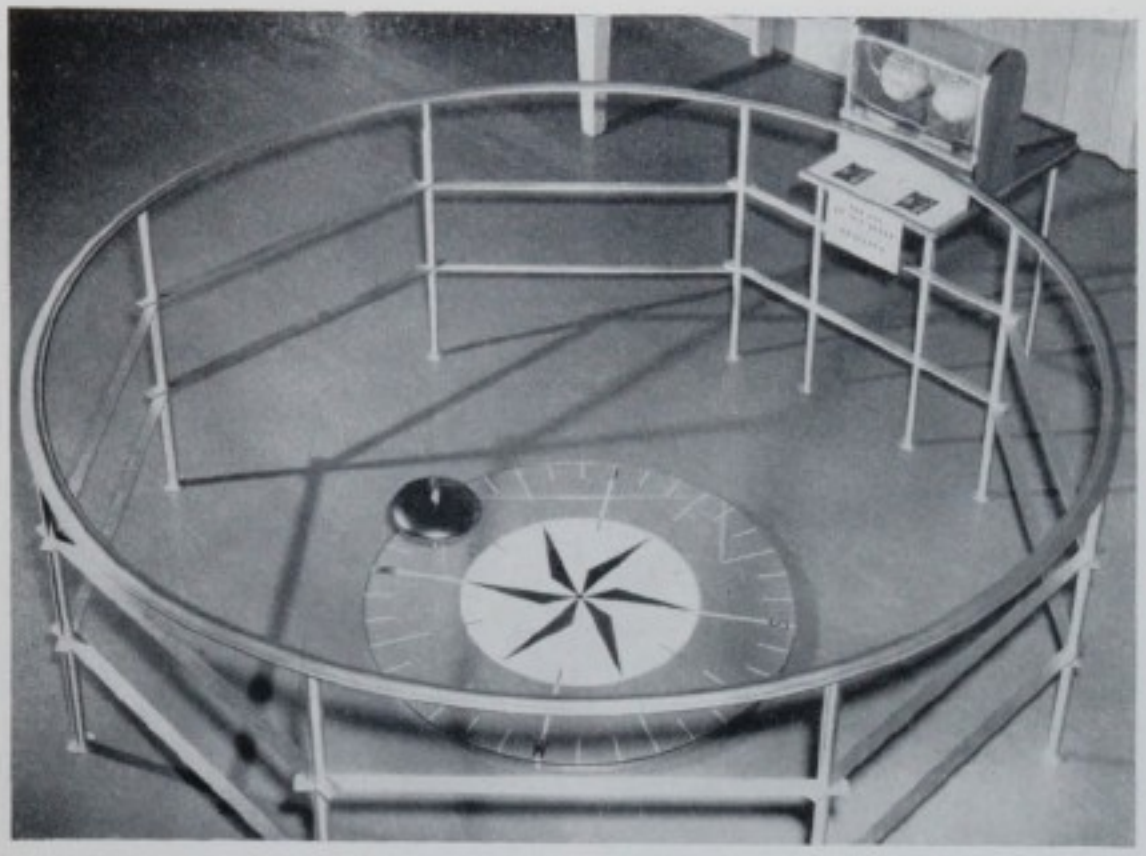
Project Ozma's first experiments will be performed with the 85-foot Howard Tatel radio telescope, pending completion of the great 140-foot paraboloidal antenna at Green Bank. In this picture, the latter's concrete pier is almost finished, and cranes 186 feet high have been erected to lift parts of the telescope into place. When assembled, the polar axis, two pieces of which are in the foreground, will weigh about 800 tons. It is made of six- and eight-inch plate and of high-density concrete. The 140-foot aluminum dish is to have a surface accurate to within a quarter of an inch, in any position. All of the receivers will be housed inside the pedestal, which has as much depth below ground as height above it. Photograph from National Radio Astronomy Observatory.

PIONEER RADIO TELESCOPE

About 25 years ago, at Wheaton, Illinois, Grote Reber used a 30-foot paraboloidal antenna for pioneering studies of radio noise from the Milky Way. His instrument is now being remounted at the National Radio Astronomy Observatory. It will complement the 85-foot steerable telescope already in use at Green Bank, West Virginia, as well as the 140-foot instrument now nearing completion.

During World War II, the Reber instrument was requisitioned by the government, but by 1955 its parts had been placed in storage at the National Bureau of Standards in Boulder, Colorado. Mr. Reber is supervising the remounting at Green Bank. This radio telescope is of sufficient size to be used for experimental purposes, in addition to having historical interest.

The Reber telescope is only one of many topics in a long article by Richard M. Emberson in *Science* for November 13, 1959. He gives a full account of the development of NRAO, with special emphasis on the difficult problem of protecting its observing programs against man-made radio noise.



The new Foucault pendulum of the Museum of Science at Springfield, Massachusetts, is the work of the local amateur astronomy club. They built the pendulum bob and its ceiling support, the model exhibit (upper right), and the floor chart. Ten-degree intervals marked on the chart correspond to the pendulum's apparent change of direction in an hour, which is easily noticed by visitors to the museum (see front-cover picture). The pendulum behaves as predicted, but swings in a narrow ellipse after an hour or two. This ellipsing is scarcely appreciable, however, because the Springfield pendulum is restarted several times each day. Photograph by William K. Buxton.

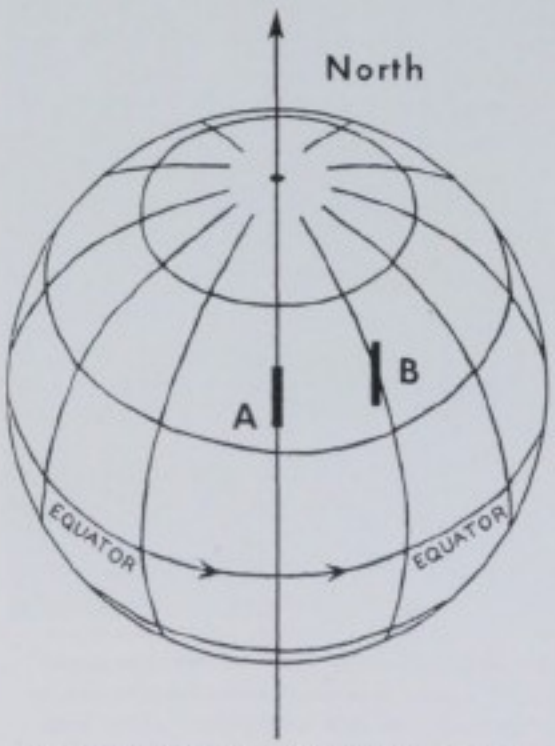
A Foucault Pendulum

WARREN I. FILLMORE, *Springfield Stars Club*

WHEN the Springfield Museum of Science celebrated its 100th anniversary recently, a Foucault pendulum was presented to it by our local astronomical society, the Springfield Stars Club. The device was designed, built, and installed by members of the group, with generous support from many business firms of this Massachusetts community. The new exhibit has been open to the public since June 5, 1959.

It is gratifying to watch the spontaneous interest adults and children alike show in this demonstration of the earth's rotation. As soon as each class of school children or a group of visitors gathers around the pendulum, the museum director, Frank D. Korkosz, starts the bob by drawing it carefully to one side and releasing it in a smooth arc without any lateral motion. He finds that this method works about as well and is more convenient than tying the bob back with a thread, which is then burned to release it.

By the time the demonstrator has finished a short talk describing the principle of the device, a change in the apparent path of the pendulum's swing can be observed. Before the group leaves the museum (perhaps after a demonstration of the Korkosz projection planetarium), the pendulum is visited again and considerable rotation can be noted. The initial amplitude of the swing is about 3½ feet, and after four hours the pendulum still swings nearly one foot.



The rotation of the earth under a Foucault pendulum at a latitude of about 40° north is shown in this sketch by the author.

The French physicist J. B. L. Foucault (1819-68) invented the experiment that bears his name. A pendulum, once set swinging, will continue to oscillate in the same plane if undisturbed. Thus, reasoned Foucault, with a suitably arranged pendulum it should be possible to show that the earth is turning beneath it.

In the cellar of his home he installed an 11-pound brass bob hung by a wire only 6½ feet long. Then, at the Paris Observatory he made a pendulum nearly 36 feet in length. But the most famous of Foucault's pendulums was suspended from the dome of the Pantheon as a science exhibit for the Paris exhibition of 1851.

There a wire 219 feet long supported a 62-pound cannon ball, to the underside of which there was attached a short stylus. A ring of sand was placed beneath the pendulum, so that on every swing the stylus cut a mark in the sand. Successive marks progressed clockwise, showing that the floor of the Pantheon was turning under the pendulum.

Foucault followed this success a year later with a duplicate proof in the form of a massive flywheel pivoting freely around its center of gravity. On being set in rapid rotation, its spin axis indicated a fixed direction in space. This was the invention of the gyroscope.

It is easy to visualize how a pendulum suspended over one of the earth's poles will show the rotation of the globe, as if the bob were swinging over a phonograph turntable. When a pendulum is hung over any point on the earth's equator, however, the plane of oscillation does not change relative to the ground beneath. A sketch of these two situations was published on page 115 of *Scientific American*, June, 1958, in an article on Foucault pendulum construction.

The situation in middle latitudes is drawn here, where **A** and **B** are taken, for convenience, to represent Springfield, Massachusetts, at latitude 42° 06′ north. Suppose we start a pendulum swinging at **A** in the direction of the short heavy line. In two hours the earth will have turned so the pendulum will be at **B**, but as it must swing in the same direction as that in which it started, it moves along the heavy line drawn through **B**. We on the earth do not sense the terrestrial rotation directly, and therefore it seems to us that the direction of the pendulum's swing is changing.

In one hour, the amount of this apparent change is 15 degrees multiplied by the trigonometric sine of the latitude. For Springfield the sine is 0.6704, so the apparent deviation of our pendulum is approximately 10 degrees an hour, or 240 degrees per day. The following approximate values indicate the range of the pendulum's hourly rotation rate for most of the United States: seven degrees

at 28° north; eight degrees at 32°; nine degrees at 37°; 10 degrees at 42°; 11 degrees at 47° north.

This phenomenon has a variety of applications; for example, to long-range missiles and to atmospheric circulation. Thus, with our present space-age awareness, the Foucault pendulum has great educational value for adults and children alike. In early 1958, therefore, our club decided to make such a device for the Springfield Museum of Science. Before actual construction was begun, we spent a year in planning and study, including a visit to see the Foucault pendulum in the Peabody Museum of Yale University.

We decided that our pendulum bob should weigh about 30 pounds, and be large enough to be easily seen, yet not of a size that would offer too much air resistance while swinging. A lenticular shape was chosen to accord with the modern decor of the museum room where the pendulum was to be mounted.

From a local supplier we obtained two identical hard-drawn aluminum shells, of just the right size and with a coppertone anodized finish. Placing the two halves together made the hollow casing of the bob, 9¼ inches in diameter and three inches thick at the center. We could not pour molten lead into the shells, as the heat might have scorched the anodized finish irreparably. Therefore, to give enough weight to the bob, we filled it with lead shot cemented into a mass with cold liquid solder.

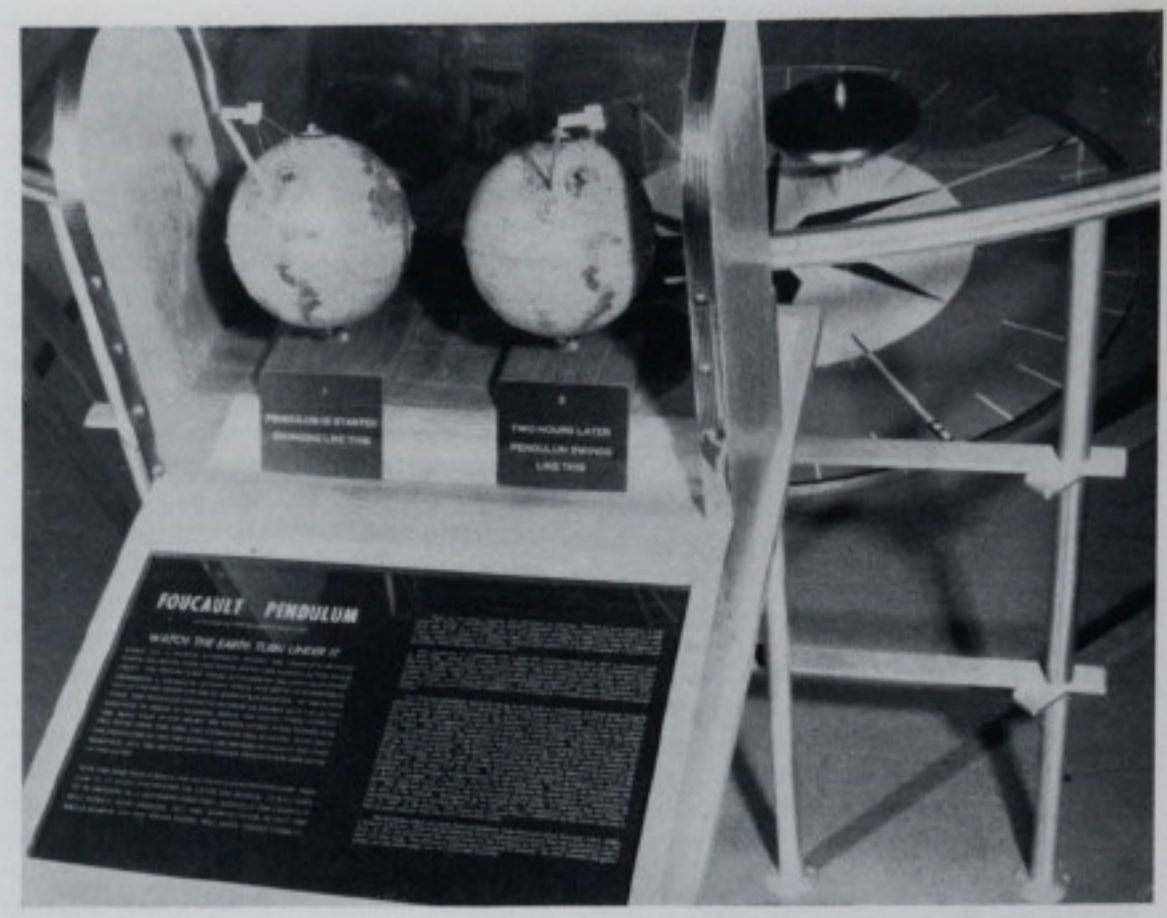
This procedure made counterbalancing easy. We hung the bob over a carefully leveled plate, on which was a surface gauge with a scribe point that was aligned with the equatorial seam of the shell. This test showed the bob was not exactly level, but by taping lead shot to the lighter side we quickly determined how much weight had to be added there. The bob was opened and the required amount of lead cemented inside; after three such trials the bob's balance seemed perfect. The care spent at this stage was repaid by the good performance of the final pendulum.

Because ours was to be an educational demonstration, primarily for school children, we decided against using any driving device or mechanical, magnetic, or electrical gadgetry that might be difficult to explain to the public.

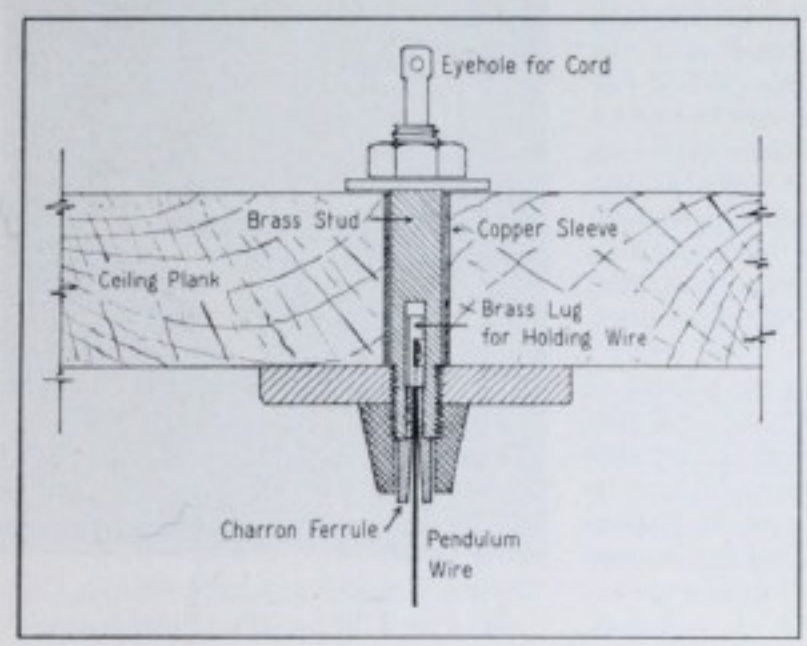
The museum room for the pendulum is only 20 feet high, but there is a crawl space above the ceiling that is accessible without ladders. A mahogany plank, whose center carries a copper sleeve, was screwed to the ceiling joists and carefully leveled. After first being unbolted from above, the whole wire-attachment assembly can be lowered to the museum floor and raised into place again by a cord. Ladders or staging are not required for cleaning, inspecting, or wire changing.

In our planning discussions, Mr. Korkosz advised us that he would like to make a fresh start of the pendulum for at least two classes of school children daily, as well as upon opening the museum for regular public hours each afternoon. This requirement indicated the possibility of unexpected stresses on the suspension wire, but our early experiments were unsuccessful because we used too thin a wire and an improper supporting fixture.

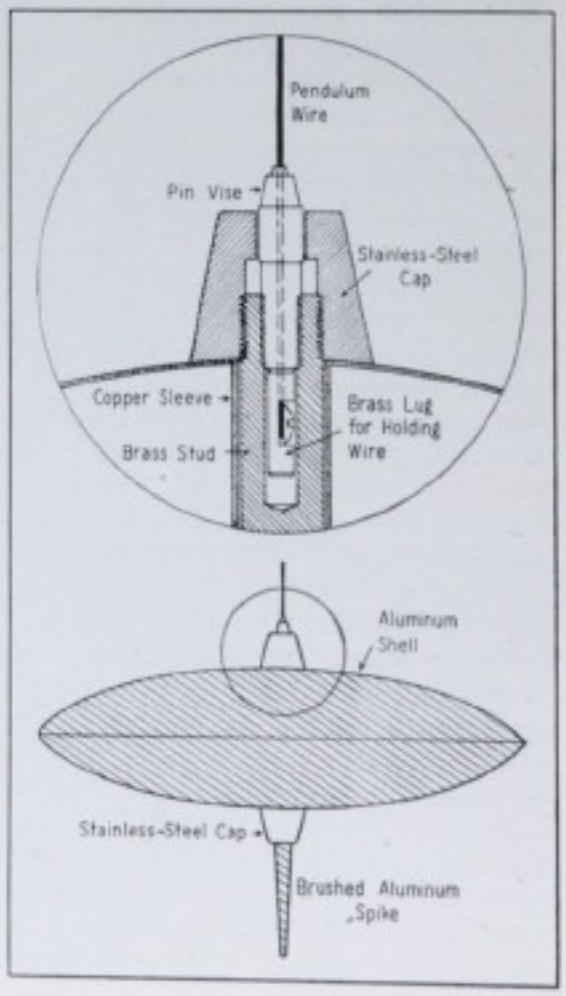
With a pendulum only about 20 feet long, if the upper end of the wire is simply clamped and allowed to flex freely, there is a wire-breaking hazard because of the large bending angle, if the amplitude of the swing is several feet. We



In this explanatory display, helpful for the viewer's understanding of the Foucault pendulum's operation, the globes bear miniature pendulums and show the earth's rotation in two hours. The amount of pendulum shift for Springfield's latitude is clearly indicated. Photograph by William K. Buxton.



Left: A sectional diagram of the final design of the pendulum's ceiling fixture, showing the gentle curve of the long Charron ferrule.



Right: The manner in which the bob is held to the wire is given in detail in the top diagram, corresponding to the part within the circle of the bottom sketch.

first used a modified pin vise to hold the wire (like the one holding the bob), and chamfered the corners of its jaws to remove sharp edges, giving a bending radius of about 1/16 inch.

This wire broke in three weeks! The bob dropped a few inches onto the glass plate covering the floor chart, but remained undented and the glass did not break. No damage resulted.

The experience proved to us the importance of adequate wire size and bending radius. We now use the Charron ferrule shown in the sketch, which prevents the wire from flexing to a radius shorter than five inches. While we expected that no bending breakage may occur for years, as an added safeguard we increased the size of the wire itself.

Most Foucault pendulums use piano wire to support the bob, although we have heard of two that use bronze. We finally decided on a stainless-steel spring wire, type 302, of diameter 0.032 inch. It has a minimum tensile strength of 277,000 pounds per square inch. But 10 per cent should be deducted for wire straightening, and 30 per cent for handling stresses, flexing fatigue, and possible defects such as nicks. At 60 per cent of its rated tensile strength the wire can support 133 pounds. Using a 30-pound bob, therefore, our safety factor is about 4.5, which should be satisfactory.

Clamping the 30-pound bob to the end of a slippery stainless-steel wire only 1/32 of an inch in diameter is no small problem. After some tests with a pull scale, we found that brass wire-holding lugs with brass set screws worked well and did not damage the wire. The "eye" on each end of the wire was carefully formed with round rat-nose pliers, the "eye" being made in a counterclockwise direction so that the pull on the wire tended to tighten the set screw. A modified Starrett pin vise prevents lateral motion of the wire and can be used with another wire size, if necessary. Periodic inspections and replacement of the wire at regular intervals are planned.

To keep spectators at a suitable distance from the swinging pendulum, a circular space eight feet across is enclosed by an aluminum railing, the materials having been donated to our project by Alcoa Aluminum. Centered in this space is a floor chart of paper, mounted on a very flat sheet of Novoply board and covered with glass. On the light blue background of this chart is a compass rose in dark blue and white. Because our floor turns 10 degrees per hour under the swinging pendulum, the chart is marked with 36 one-hour divisions and the compass rose has six points instead of the customary eight.

The whole project cost our club just under $100, thanks to materials and effort contributed by many firms and individuals. Were it not for this help, the cost of the exhibit might have been several thousand dollars.

NEWS NOTES

UNUSUAL IRREGULAR GALAXY

Messier 82, visible in amateur telescopes as a 9th-magnitude patch of light in Ursa Major, is one of the nearest and brightest galaxies that are irregular in shape. Most irregular galaxies owe their light chiefly to large numbers of hot, blue stars within them, and these galaxies are in fact usually bluer in color than the sun.

However, M82 departs from this rule, according to W. W. Morgan, Yerkes Observatory, and N. U. Mayall, Lick Observatory. While this system is found from spectroscopic observations to contain a great many blue stars, the galaxy appears distinctly redder than the sun.

This contradiction has now been explained by observations made at McDonald Observatory during the spring of 1959. From the behavior of the emission lines of hydrogen and oxygen, the two astronomers have found that M82 is immersed in a great complex of dust, which reddens and dims the light of stars imbedded in it. Other irregular galaxies, on the contrary, seem to be relatively transparent and free from dust.

LUNAR RAY FORMATION

Among the full moon's most conspicuous surface features are the long, narrow, bright streaks diverging from the crater Tycho. Other rays are associated with such craters as Copernicus and Aristarchus. Many of the rays if extended backward, however, do not pass through the center of the crater involved, and some of them appear to be double. It has been suggested that material ejected explosively from a crater would be projected to great distances and that the displacement of the nonradial rays was caused by rotation of the moon during the flight of the debris.

A further proposal has been made by Louis A. Giamboni, of the Rand Corp., in the July, 1959, *Astrophysical Journal*. He points out that large terrestrial explosions indicate that ejection, whether from meteoritic impact or volcanic craters, could occur in vertical fans with restricted extent in azimuth. Material projected vertically upward would have fallen east of Tycho, for example, because the moon was rotating during the relatively long time of flight. Debris that moved in low trajectories would fall sooner and suffer less deviation. Some fans might produce double rays, the high-trajectory nonradial branch lying to the east of the low-trajectory one in each case.

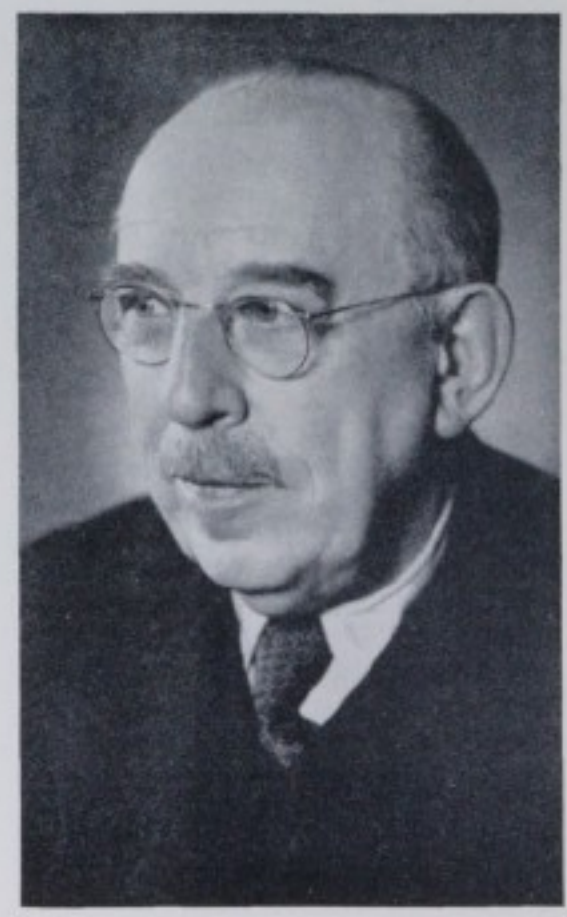
Dr. Giamboni compared the pattern of 68 Tycho rays or segments of rays with the predictions of his model. He finds that the Tycho ray system could have its actual form only if it were laid down when the moon was rotating much more rapidly than it does now, with a period between 0.5 and 6.8 days. It is known that the moon's rotation has been gradually slowing down as a consequence of tidal friction. While this process has a highly uncertain time scale, Dr. Giamboni has used it to deduce that the ray system was produced less than 80 million years after creation of the moon itself. This would be roughly contemporary with the formation of the lunar tidal bulge.

PLANETARIUM INVENTOR DIES

Perhaps no one person has done more for the popularization of astronomy than Walther Bauersfeld, chairman of the board of directors of the Carl Zeiss Works, Oberkochen, West Germany, who died on October 28, 1959, in his 80th year.

In 1919 he conceived the idea of the modern projection planetarium, designing and building the first instrument of this type, which was installed at the Deutsches Museum in Munich in May, 1925. Since then more than 30 other Zeiss projectors have been erected in various parts of the world, including six in the United States.

Professor Bauersfeld was the first to apply modern technology to the historic idea of a planetarium. By using optical projection to show every naked-eye star in its proper position, and by developing special projectors to present planetary motions in full detail, he obtained a highly realistic representation of the night sky and the annual panorama of the constellations. In this way, Professor Bauersfeld has been responsible for introducing the wonders of the heavens to vast multitudes of people.



Walther Bauersfeld (1879-1959), inventor of the Zeiss projection planetarium.

IN THE CURRENT JOURNALS

ENERGY AS AN ULTIMATE RAW MATERIAL, by Alvin M. Weinberg, *Physics Today*, November, 1959. "I choose to dwell on energy, first, because as physicists our basic subject of study is energy; and, second, because the character of the asymptotic state of mankind — whether it will be a bare existence or a passably abundant life — will depend centrally on our capturing an inexhaustible energy supply, either by learning how to burn the seas (fusion) or to burn the rocks (fission) or to trap the sun's energy in a practical way."

GENERAL MAGNETIC FIELD OF THE SUN

Since 1952, systematic measurements of the general magnetic field of the sun have been made by Harold D. Babcock of Mount Wilson and Palomar Observatories (SKY AND TELESCOPE, October, 1954, page 423; September, 1958, page 555).

During the first five years of this program, the solar field's polarity remained unchanged — being opposite in sign to that of the earth's magnetic field. But by June, 1957, the field had become much weaker, and near the sun's south pole the polarity had changed. Dr. Babcock now reports that a gradual reversal of polarity has spread over the entire sun, the change in the north polar region being first observed in November, 1958.

It has long been known that the magnetic polarity of sunspots varies in a 22-year cycle. The polarity of pairs of spots in the sun's northern hemisphere is opposite to that in the southern hemisphere, and these reverse every 11 years. Dr. Babcock suspects that the general magnetic field may also reverse polarity in a 22-year cycle, but the observations must be continued for many years to verify this idea.

RADIO STORM IN SUN'S CORONA RECORDED

During a 10-day period last May, beginning about the 10th, solar activity was very marked. A flare of importance 3+ was observed (SKY AND TELESCOPE, August, 1959, page 544), with radio bursts being recorded on many wave lengths. Observations at frequencies up to 580 megacycles per second were made at Harvard's radio astronomy station in Texas.

Intense long-wave radio emission originating high in the sun's corona was observed during the 10-day period by W. C. Erickson, at the Clark Lake radio astronomy station of Convair Scientific Research Laboratory, in southern California. The high-energy disturbance was about 1.3 to 1.7 million miles above the visible surface of the sun. As observed at a wave length of 11.4 meters (frequency 26.3 megacycles per second), the region emitted radiation about 100 times more intense than the normal background radio noise from the corona.

Simultaneously, cosmic ray scientists at the University of Minnesota recorded a tremendous gain in the flow of protons of half-billion electron volt energies. This flux was 1,000 times above normal, and was believed to originate in the sun's vicinity rather than in the Van Allen radiation belts surrounding the earth.

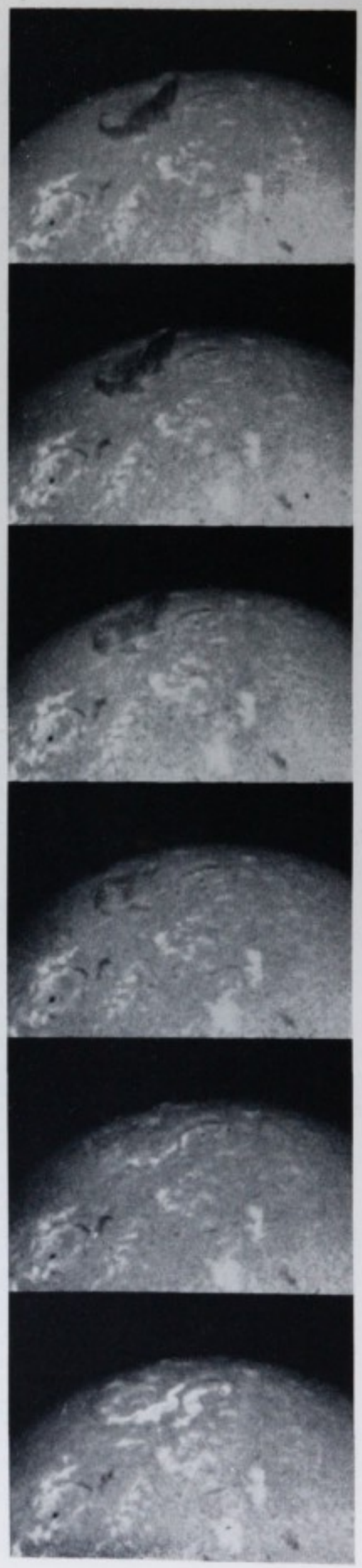
Dr. Erickson's observations were made with the completed portion of a large radio interferometer being erected on the very flat bed of Clark Dry Lake, about 90 miles northeast of San Diego, where it is shielded from man-made radio interference by mountains on three sides. When fully assembled, it will consist of a rectangular array of 256 copper-wire dipoles, suspended from posts in eight parallel rows to form an east-west band two miles long. The beam resolving power in this direction is to be about $\frac{1}{4}$ degree, and north-south it will be $1\frac{1}{2}$ degrees.

FLARE-PATROL PHOTOGRAPHS

At Sacramento Peak Observatory in New Mexico, a telescope for recording flares and other activity on the sun is in daily use by Harvard astronomers under a contract with the Air Force Cambridge Research Center. The accompanying sequence of pictures taken on September 1, 1959, furnishes a good example of the disappearance of the dark filament of a large solar prominence, followed by the growth of a flare in the same region.

The six pictures (top to bottom) were exposed at 18:33, 19:02, 19:10, 19:15, 19:27, and 19:58 Universal time. The prominence first appears as a broad dark cloud not far from the upper edge of the sun, then fades away entirely. Nearby, activity in the sun's chromosphere increases and the bright flare grows to an importance of 2+. The pictures were taken in the red hydrogen-alpha line of the solar spectrum, this being the wave length at which both prominences and flares are usually recorded.

Few other solar or terrestrial phenomena appear to have been associated with the flare. A magnetic crochet of intensity 15 gammas occurred at 19:17, just before the start of the flare itself, but there was no sudden cosmic noise absorption or sudden enhancement of atmospherics. At Ft. Davis, Texas, the Harvard solar radio telescopes recorded an intense group of fast-drift bursts between 19:51 and 20:05 at 25 to 100 megacycles, as well as continuum radiation on the 300-to-580-megacycle band throughout the lifetime of the flare.



A region of the solar chromosphere in Hα light, from the flare-patrol records of Sacramento Peak Observatory. They were selected by William D. Booton to illustrate the disappearance of a prominence and the eruption of a flare. Courtesy Air Force Cambridge Research Center.

The Practical Use of Ephemeris Time

G. M. CLEMENCE, *Nautical Almanac Office, U. S. Naval Observatory*

INTRODUCTION of Ephemeris time into the national ephemerides for 1960 may produce confusion in the minds of some people who have not read the numerous articles on the subject in the astronomical literature of the past 10 years. My purpose here is to discuss the matter from a strictly practical point of view, and to give some precepts which, it is hoped, will prevent misunderstandings or mistakes.

The important thing to remember is that highly precise predictions must be referred to Ephemeris time, and highly precise observations to Universal time. The two can be brought together only approximately at first, and with full precision after some months or years.

It has been known for more than two decades that Universal time, which is based on the rotation of the earth, is not suitable for the precise description of astronomical phenomena. The speed of rotation of the earth changes occasionally in an irregular and unpredictable fashion, causing variations in Universal time. It would be all very well if the variations could be calculated in advance, for then allowance could be made for them in the prediction of astronomical phenomena, but that is not the case; it is the unpredictable character of the variations that produces the trouble.

These changes are due to some activity deep within the earth, of a more or less random character. The activity has, of course, been going on for millions of years, but it is only within the last century that astronomical observations and calculations have become precise enough to show the effects, and only during the past few decades has it been possible to rule out all other explanations.

A better measure of time is needed for refined astronomical purposes, and is provided by Ephemeris time, based on the revolution of the earth around the sun, and determined from year to year by the revolution of the moon around the earth. Neither the orbital motion of the earth nor that of the moon is uniform, but the variations can be very precisely calculated and allowed for, so that we obtain a uniform measure of time.

At once the question arises: Why not dispense with Universal time altogether, and rely exclusively on Ephemeris time? There are several reasons why such a course would be inadvisable, and at least one why it is impossible. That reason is the practical necessity for navigators and surveyors to find their longitudes on the surface of the earth. They cannot carry with them the complicated equipment that is needed for determining Ephemeris time, and even if they could, they would not have enough time or the training to use the equipment.

The only practical way for them to find their longitudes is to make a simple observation determining local mean time, and to compare the result with Greenwich mean time, which is the same as Universal time. Thus, it is clear that radio time signals must be broadcast as Universal time, and it follows that ordinary clocks must be set to Universal time (or to some zone time based on it); otherwise intolerable chaos would result.

Another reason why the general use of Ephemeris time would be inadvisable is the accuracy with which it is known at any moment. At the instant when an observer records an observation, only the Universal time can be known with such high precision that no subsequent correction is necessary. If the observer used Ephemeris time instead, he would first have to record only an approximate value, and several months or years later go back and correct it. Obviously such a course would lead to unnecessary labor, confusion, and mistakes. *Observers should continue to use Universal time.*

If he wishes, however, the observer may immediately compare his observation with a prediction that has been made in Ephemeris time. He need only add to the Universal time an approximate value of the difference between the two, printed in this table from the *American Ephemeris*. He will then have an approximate value of the Ephemeris time, but it is subject to revision and should not be used when his observation is published.

It should be noted that some of the data in the *American Ephemeris* are referred to Ephemeris time and some to Universal time. The latter (excepting pages 10-17 in the 1960 volume) are of lower accuracy, where an error of a second or so is of no consequence, as in the ephemerides for physical observations of the sun, moon, and planets.

Particular care is necessary to avoid confusion about Julian dates. Normally these are in Universal time (counted from

ΔT

REDUCTION FROM UNIVERSAL TIME TO EPHEMERIS TIME

Add to Universal Time

	s	d		s	d		s	d
1901.5	− 2.54	−.000029	1921.5	+21.06	+.000244	1941.5	+24.71	+.000286
1902.5	− 1.13	−.000013	1922.5	21.56	.000250	1942.5	25.15	.000291
1903.5	+ 0.35	+.000004	1923.5	21.97	.000254	1943.5	25.61	.000296
1904.5	1.80	.000021	1924.5	22.29	.000258	1944.5	26.08	.000302
1905.5	3.26	.000038	1925.5	22.55	.000261	1945.5	26.57	.000308
1906.5	+ 4.69	+.000054	1926.5	+22.72	+.000263	1946.5	+27.08	+.000313
1907.5	6.11	.000071	1927.5	22.82	.000264	1947.5	27.61	.000320
1908.5	7.51	.000087	1928.5	22.92	.000265	1948.5	28.15	.000326
1909.5	8.90	.000103	1929.5	23.05	.000267	1949.5	28.94	.000335
1910.5	10.28	.000119	1930.5	23.18	.000268	1950.5	29.42	.000341
1911.5	+11.64	+.000135	1931.5	+23.34	+.000270	1951.5	+29.59	+.000342
1912.5	12.95	.000150	1932.5	23.50	.000272	1952.5	30.21	.000350
1913.5	14.18	.000164	1933.5	23.60	.000273	1953.5	30.8	.00036
1914.5	15.31	.000177	1934.5	23.64	.000274	1954.5	31.0	.00036
1915.5	16.39	.000190	1935.5	23.63	.000273	1955.5	31.5	.00036
1916.5	+17.37	+.000201	1936.5	+23.58	+.000273	1956.5	+32	. . .
1917.5	18.27	.000211	1937.5	23.63	.000273	1957.5	33	. . .
1918.5	19.08	.000221	1938.5	23.76	.000275	1958.5	33	. . .
1919.5	19.83	.000230	1939.5	23.99	.000278	1959.5	34	. . .
1920.5	+20.48	+.000237	1940.5	+24.30	+.000281	1960.5	+35	. . .

Where values are given to 0^s.1, they are based on incomplete observational data; those that are given to whole seconds are extrapolated. These values will usually prove to be correct; but the end figure may later be revised on the basis of further observational data.

The values previous to 1949.5 are those of BROUWER, *Astronomical Journal*, **57**, 133, 1952; his table of ΔT extends over most of the 19th century.

This table, reproduced from the "American Ephemeris and Nautical Almanac" for 1960, gives the differences between Universal and Ephemeris times.

noon instead of midnight, for historical reasons), as is implied by their being a count of days. Universal time is always understood as being used when more than one decimal of a day is given, unless expressly stated otherwise. It may occasionally be desirable to express Ephemeris time in a form resembling Julian dates, using five or six decimals of a day, but then care must always be taken to label them Julian ephemeris dates. When only one decimal of a Julian date is given, it should be evident from the context what is meant. For example, in the 1960 *American Ephemeris,* the Julian dates on pages 10-17 are clearly in Universal time, whereas those on pages 160-177 are in Ephemeris time, and might better have been labeled Julian ephemeris dates.

It is to some extent illogical to reckon Ephemeris time in days, hours, minutes, and seconds. The logical procedure, which was actually proposed by one astronomer, would have been to count it in years and decimals of a year, since it is defined in terms of the year and has no exact relation with the day. In that case it would be necessary, in order to compare the two kinds of time with each other, to be continually multiplying and dividing numbers.

To avoid this inconvenience, Ephemeris time is conventionally expressed in days, hours, minutes, and seconds, but the thing called a day in this connection is merely an arbitrary unit consisting of 86,400 ephemeris seconds, and is only approximately equal to one actual day. The ephemeris second, in turn, is not exactly 1/86,400 of a day, but by definition is 1/31,556,925.9747 of a tropical year.

Observing astronomers, then, should not make any change in the practices they have always followed. On the other hand, the users of the observations can reform their customary procedures and obtain more accurate results. Consider the case of an astronomer wishing to calculate a really precise orbit for a minor planet, using observations made in a number of different years. He collects the observations from the literature, but before using them changes the time of each by adding the particular correction necessary to convert it from Universal to Ephemeris time. He does this in all cases, whether the observation was made earlier than 1960 or later.

Once this has been done, the observations are on the same basis as the published ephemerides of the sun and principal planets – despite the label "Universal time" that was printed above the ephemerides before 1960, a misnomer we used in our ignorance for want of a better. (The user may, if he wishes, go through the old volumes with a rubber stamp, altering the designations from Universal to Ephemeris time, but he will probably prefer to imagine the alteration made, without actually making it.) With the observations thus referred to Ephemeris time, the astronomer can proceed exactly as he used to, but if at the end of his work he prepares an ephemeris, he should label it Ephemeris time, instead of Universal time as formerly.

The U. S. Naval Observatory will furnish the latest estimates of Ephemeris time upon request to any astronomer who needs them for orbit work, the estimates being based on observations more recent than the data on page viii of the 1960 *American Ephemeris.* In the case of very recent observations, Ephemeris time cannot be determined with the highest precision, and the user must decide whether to discard such observations or to be satisfied with an approximate conversion to Ephemeris time.

The innovations described have not been lightly made, and certainly not for the convenience of those who made them. Indeed, all persons concerned would have been glad to avoid the difficulties. But in the commissions of the International Astronomical Union that have jurisdiction in this matter, opinion was unanimous that the changes were necessary for the continued advancement of astronomy.

198 MARS, 1960

FOR 0h EPHEMERIS TIME

Date		Apparent Right Ascension		Apparent Declination		Semi-diameter	Hor. Par.	True Distance from the Earth		Ephemeris Transit
		h m s	s	° ′ ″	″	″	″			h m s
July	1	2 23 03·56	+166·53	+12 50 55·4	+ 852·9	3·02	5·67	1·551 256	− 4 715	7 46 30
	2	2 25 50·09	166·53	13 05 08·3	844·6	3·03	5·69	·546 541	4 724	7 45 20
	3	2 28 36·62	166·55	13 19 12·9	836·2	3·04	5·71	·541 817	4 734	7 44 10
	4	2 31 23·17	166·55	13 33 09·1	827·7	3·04	5·73	·537 083	4 745	7 43 00
	5	2 34 09·72	166·56	13 46 56·8	819·0	3·05	5·74	·532 338	4 755	7 41 50
	6	2 36 56·28	+166·56	+14 00 35·8	+ 810·3	3·06	5·76	1·527 583	− 4 767	7 40 40
	7	2 39 42·84	166·58	14 14 06·1	801·6	3·07	5·78	·522 816	4 778	7 39 30
	8	2 42 29·42	166·58	14 27 27·7	792·7	3·08	5·80	·518 038	4 790	7 38 20
	9	2 45 16·00	166·59	14 40 40·4	783·7	3·09	5·82	·513 248	4 804	7 37 10
	10	2 48 02·59	166·57	14 53 44·1	774·6	3·10	5·83	·508 444	4 817	7 36 00

330 MARS, 1960

EPHEMERIS FOR PHYSICAL OBSERVATIONS

FOR 0h UNIVERSAL TIME

Date		Light-Time	Stellar Magnitude	Diameter	$A_E+180°$	D_E	A_S-A_E	D_S	L_S
		m		″	°	°	°	°	°
July	1	12.89	+1.0	6.03	131.63	−17.42	−42.31	−23.98	269.37
	3	12.81	1.0	6.07	133.06	17.00	42.38	23.98	270.63
	5	12.73	0.9	6.11	134.48	16.57	42.43	23.97	271.88
	7	12.65	0.9	6.15	135.89	16.14	42.47	23.95	273.12
	9	12.57	0.9	6.18	137.29	15.70	42.50	23.91	274.37

Two samples of "American Ephemeris" predictions for Mars. In the first, containing precise daily co-ordinates of the planet, the appropriate heading is Ephemeris time. But in the second table, used primarily by observers, the tabulated values change so slowly from day to day that the difference between Universal and Ephemeris time is not significant, and the more suitable label is Universal time. The five last columns in the physical ephemeris of Mars specify the locations of the earth and sun with respect to that planet.

GEOCHEMICAL TABLE OF THE ELEMENTS

To ascertain the abundances of the chemical elements in the earth's outer layers is an exceedingly intricate problem. For each element, an over-all result can be obtained only by carefully combining results from many analyses of minerals, rocks of different types, sea water, and other materials. Geochemists in many countries are actively working on this problem, using many recent refinements in analytical methods. As a result, geochemical data determined only a few years ago often are already obsolete.

For this reason, Jack Green of Aero-Space Laboratories, Downey, California, has compiled a very extensive tabulation of the best modern values on the composition of the earth, which appeared in the September, 1959, *Bulletin* of the Geochemical Society of America. His listing is presented as a chart measuring two by four feet, in the form of a periodic table of the elements. For each element, he gives such data as its abundance in igneous, metamorphic, and sedimentary rocks, as well as in meteorites and in the cosmos. Also, there are tables of isotopes, and extensive data on physical, chemical, and nuclear properties.

Twenty-six pages are required to list the references cited in the author's element-by-element review of abundance distribution.

In Focus

FACING this page is one of the remarkable series of lunar photographs taken nearly 60 years ago by George W. Ritchey (1864-1945), with the 40-inch refractor of Yerkes Observatory. He is famed as the maker of the mirrors for the 60-inch and the 100-inch Mount Wilson reflectors. Both a gifted builder of telescopes and a skilled user of them, he could expose a plate with the 60-inch that after 11 hours of guiding showed perfectly circular star images.

Because the large Yerkes refractor has an objective designed for visual observing, Ritchey used a yellow filter and isochromatic plates for photographing the moon. The great focal length of this telescope — 63½ feet — and its optical excellence made it an exceptionally effective instrument for this work, when the seeing conditions were suitable. This combination of man and instrument explains why Ritchey's lunar photographs of 1900-01 are still among the finest ever made.

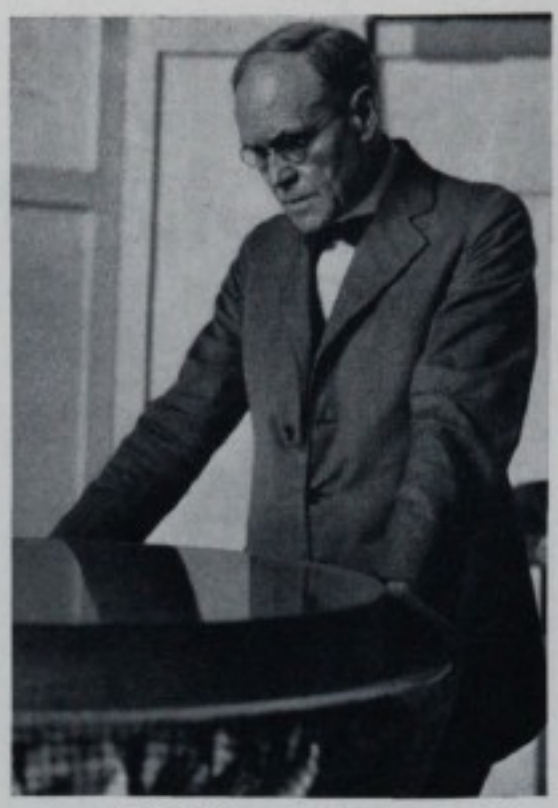
In the picture, the moon is about five days past full, and the lunar time of day in this region is late afternoon. North is below and west to the left, corresponding to the orientation of the moon's disk in an inverting telescope. (In selenographical usage, the directions east and west are opposite to those on earth; as seen from the moon, the sun rises in the west and sets in the east!) For convenience in referring to individual features, we shall use such notations as (2, 3), which indicates a point two inches from the left edge of the page and three inches from the upper edge.

Covering most of the lower half of this moonscape is the dark oval plain, Mare Serenitatis. Toward the upper left, it merges into the crater-strewn sea Mare Tranquillitatis, and at the right edge is part of the dark expanse of Mare Vaporum.

Many lunar ridges are shown to advantage in this photograph. The most conspicuous is the aptly named Serpentine ridge, running north and south in the western part of Mare Serenitatis. It rises about 600 feet above the surrounding plain, becoming higher near its northern end (1¾, 8½), where it forks into two branches. The numerous other ridges in this sea are all lower. One of these, extending northward from the crater Bessel (4, 6¾), is only 100 feet high, according to J. F. J. Schmidt. It underlies a bright streak which is discussed by Alika K. Herring on page 169 of this issue.

Turning now to Mare Tranquillitatis,

FACING PICTURE: This Yerkes Observatory photograph of the lunar Sea of Serenity and its surroundings was taken with the 40-inch refractor by G. W. Ritchey around 1901. The moon was about five days past full. There are a number of photographic defects in the form of black specks.



George W. Ritchey is shown here with the 60-inch mirror he ground and figured for Mount Wilson Observatory. Lately it has been used by Dinsmore Alter for taking remarkably fine lunar photographs.

we note west of the 16-mile crater Arago (4, 2) a beautiful and intricate network of very low ridges. G. P. Kuiper argues that the presence of low relief such as this in the seas contradicts T. Gold's theory that the sea basins are filled with dust to a depth of hundreds or even thousands of feet.

Just north and just east of Arago, distant from this crater by one of its diameters, are two peculiar low swellings. These are among the most conspicuous examples of the lunar domes described by Patrick Moore on page 91 of SKY AND TELESCOPE for December, 1958. Each is essentially a low flat-topped hill, with very gently sloping sides, and often surmounted by a minute craterlet. There is another small and symmetrical dome near (2¾, 3¼).

Conspicuous in this photograph are many rills or clefts — long, narrow valleys or cracks running great distances across the lunar surface. One of the most striking is the Hyginus cleft, which passes through the crater of that name, at the right edge of the page 3¾ inches from the top. To the left of it is the famous Ariadaeus cleft, which runs diagonally to the edge of Mare Tranquillitatis.

Clefts often parallel the borders of the maria. For example, look at (3, 5), just north of the crater Plinius, for three clefts that are roughly concentric with Mare Serenitatis. Analogous clefts, running just inside the boundary of Mare Tranquillitatis, can be seen at the extreme top center of the picture, just south of the crater Sabine (4¾, ¾).

Another type of lunar surface formation that has not been studied systematically is the small white patches that occur in great numbers over the maria. The largest of these inside Mare Serenitatis is Linné, at (5¼, 9). Some, but not all, of the records of Linné made before 1850 describe it as a crater instead of a bright spot, but the latter has been its habitual appearance since then. This led some writers to believe that a physical change took place in Linné, but this is strongly contradicted by the careful investigations of W. Prinz and P. Fauth, who have explained the mistakes made by the early observers.

The great variety in appearance of lunar craters is well demonstrated in this photograph. Manilius (7, 5½) is a well-formed crater about 25 miles in diameter, with terraced walls and a small central peak rising from its floor. Compare this ring with shadow-filled Plinius (2¾, 4½), whose central hill's summit just catches the last rays of the setting sun. Of a different character is Maclear (4, 3½), a ring with very low walls and a flat floor that appears nearly level with the surrounding plain, instead of depressed as is the case with normal craters. Pass 1½ inches to the right to find Julius Caesar, a large but very dilapidated crater, whose western wall is largely lacking, while the eastern rim is lofty and seemingly intact. Julius Caesar is remarkable for the differences in brightness on its floor, the northern part being very dark.

Last of the craters on this tour is Posidonius, at the left edge of the page and nine inches from the top. It is the largest of all the craters in the picture, being about 60 miles in diameter. In this view, the rays of the setting sun brightly illuminate the crest line of the ramparts, while the interior is drowned in shadow, except for some ridges, a hill, and a lesser crater that appears as a glowing ring. The amateur who views Posidonius with a large telescope under these lighting conditions will see an entrancing sight whose beauty can only be suggested by photography.

J. A.

ASTRONOMY TV PROGRAMS FROM PHILADELPHIA

The moon, Venus, and Mars will be in succession the subjects of programs in the Johns Hopkins File 7 series televised at noon on Sundays by the American Broadcasting Co. Three astronomers from Philadelphia's Franklin Institute will be featured. On January 3rd, I. M. Levitt, director of the Fels Planetarium, will discuss the moon; on the 10th John Streeter will document Venus; and on the 17th Robert W. Neathery will talk on Mars.

NEW LEUSCHNER DIRECTOR

Louis G. Henyey has been appointed director of the Leuschner Observatory and chairman of the astronomy department at the University of California, Berkeley. A member of the faculty since 1947, Dr. Henyey will continue as head of the university's computer center.

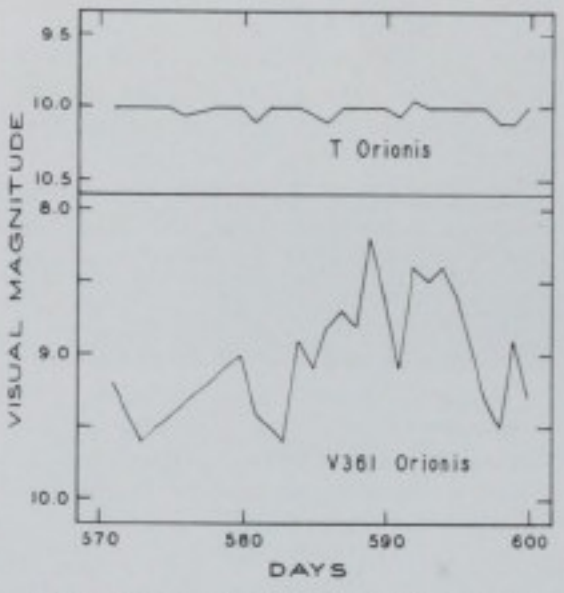
Variable Stars in the Orion Nebula

LEIF J. ROBINSON, *Griffith Observatory and Planetarium*

THE GREAT NEBULA veiling the multiple star Theta in Orion's sword has fascinated both amateur and professional astronomers ever since its discovery by Cysatus in 1618. This vast mass of softly glowing gas is a beautiful sight even in small telescopes, and an object of marvel in larger instruments.

One most interesting feature of the Orion nebula is its large number of variable stars, a characteristic not discovered until the early years of this century. These are known interchangeably as *nebular* or *extrinsic* variables. The term nebular is well suited to such objects, for they occur in abundance in the many dense patches of nebulosity that are features of the spiral arms of our galaxy.

The other adjective, extrinsic, is equally appropriate, indicating that the cause of the light variations lies not in the stars themselves, but that they vary because they are inside a nebula. The richest nest of such variables in the sky is within the bright central portion of the Orion nebula, where there are more than 50 variables brighter than magnitude 14.0 at maximum light.

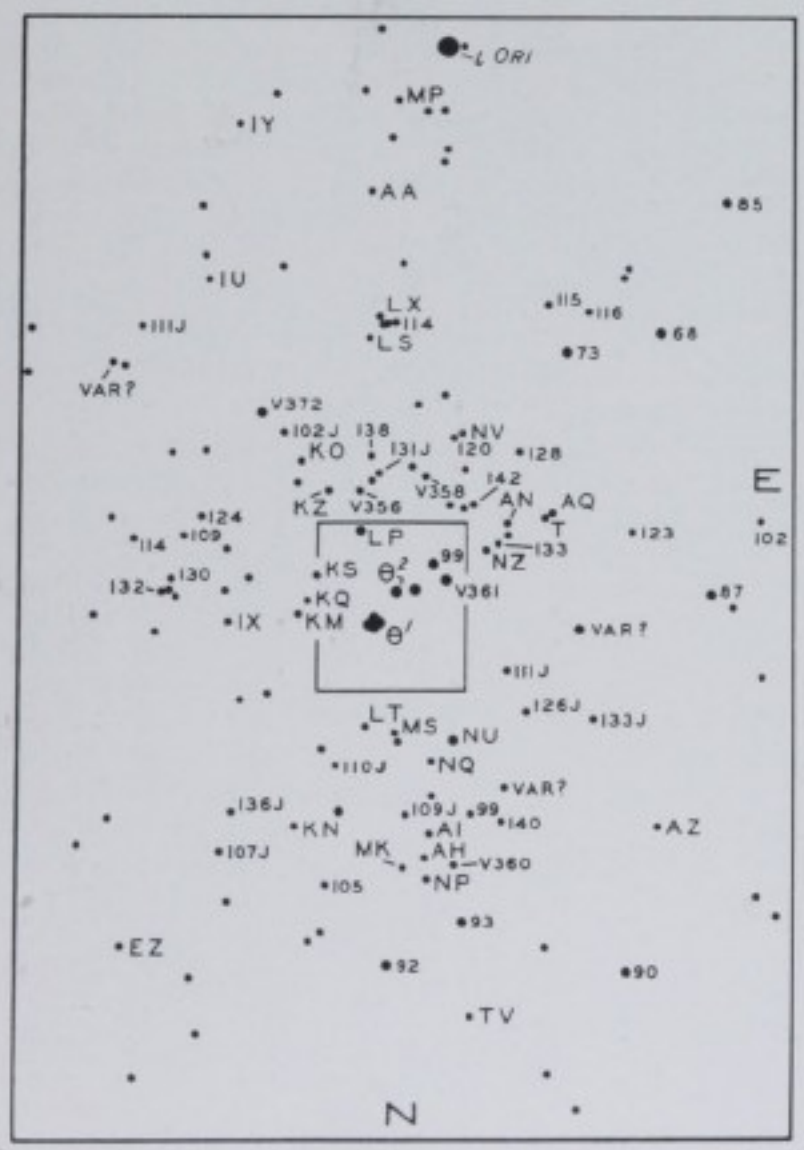


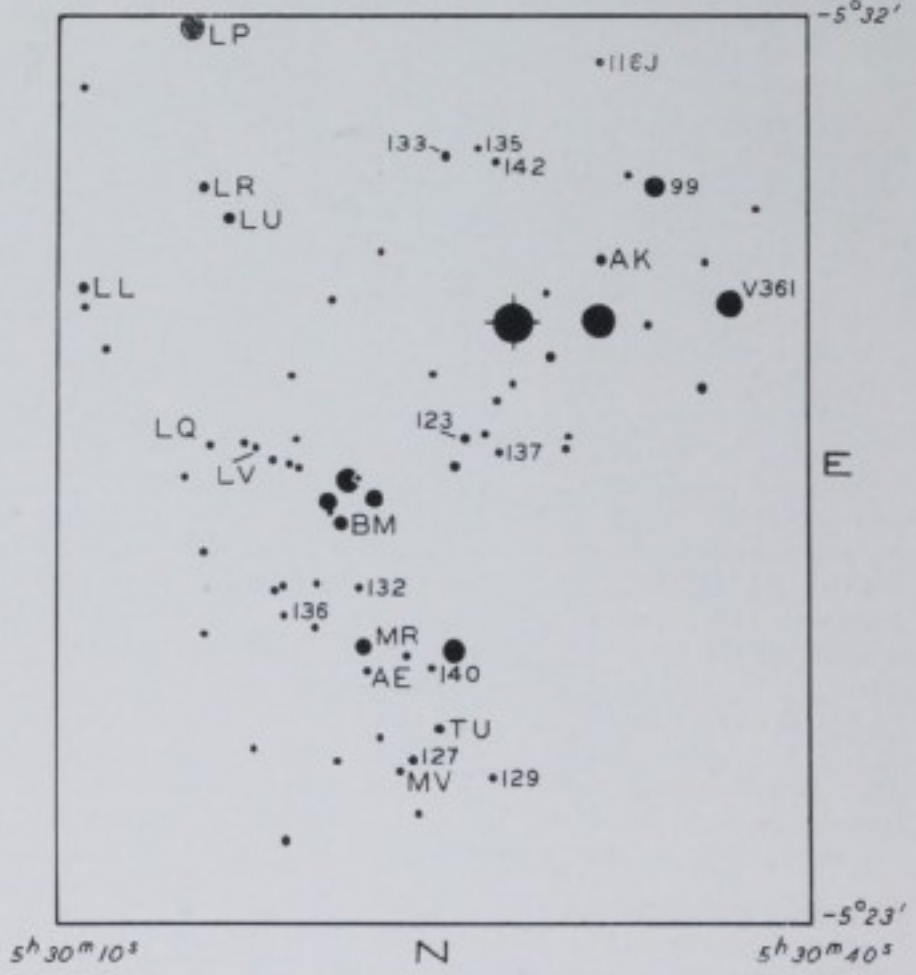
Two of L. J. Robinson's light curves for variable stars in the Orion nebula, from observations made in January, 1959. The time scale is labeled with the last three digits of the Julian day numbers. Contrast the near-constancy of T Orionis with the brisk brightness oscillations of V361 Orionis. T at times fades to magnitude 13.

At one time it was believed that the light variations were caused by a varying thickness of nebulosity drifting between us and the stars. In recent years, however, the spectra of many of the Orion variables have been observed, and found to have peculiarities indicating actual interaction between the stars and the medium in which they are imbedded.

Many of these stars are noted for the rapidity of their light variations, making them fascinating objects to observe. For example, within the past year V361 Orionis had maxima of brightness every few days. At times, however, nebular stars may remain nearly or quite constant for long intervals. Such behavior was shown last winter by T Orionis, as the accompanying light curve indicates.

The typical variable star in the Orion nebula undergoes rapid, irregular changes in brightness, with an average amplitude of 1.5 magnitudes. This is considerably smaller than the average of four or five





The author's charts for Orion variables. See the table on the facing page for details about individual stars. The map above is an enlargement of the area surrounding the Trapezium, as indicated by the box in the smaller-scale chart at the left. The variable BM is faintest of the four Trapezium stars.

The sword of Orion, recorded in a Harvard photograph and printed with south upward. The brightest star, above the nebula, is Iota Orionis, which is at the top of the small-scale chart on the facing page. Its magnitude is 2.9. The Trapezium itself is concealed in bright nebulosity, close to the "fish-mouth" indenting the nebula from the right.

magnitudes for the Mira-type variables that are commonly observed by amateurs.

The American Association of Variable Star Observers has a chart of the region of the Orion variables. Since this was last revised in 1935 and needs many changes, I began in 1957 a special study of these stars for the purpose of preparing a new AAVSO chart. Since 1935 many new variables have been found in the nebula by the Soviet astronomer P. P. Parenago, some of them stars that were supposedly nonvariable and thus were used as magnitude standards on the original AAVSO map.

The new chart is shown here, together with a supplement, on enlarged scale, of the crowded region immediately surrounding the Trapezium, which is Theta Orionis itself. A good selection of variable stars is given, most of them bright enough to be observable in amateur telescopes of medium size.

On these maps, comparison stars are labeled with their magnitudes to the nearest tenth, decimal points being omitted to avoid confusion with star symbols. The suffix J indicates that the magnitude was determined photoelectrically by H. L. Johnson (*Astrophysical Journal, 126,* 134, 1957); such magnitudes are preferred, as being more accurate, in cases where the observer has a choice of comparison stars.

Systematic co-operative observations of the variables in the Orion nebula have been carried out by Thomas A. Cragg, Inglewood, California (12-inch reflector and 6-inch refractor), Brian Bell, Hollywood, California (6-inch reflector), and myself with a 10-inch reflector. In addition, all three of us shared the use of the Griffith Observatory 12-inch refractor.

The first observations were made in September, 1958. At that time a preliminary chart was prepared that contained 59 variables brighter than magnitude 14.0 at maximum light. In the version presented here, this number has been reduced to 45 stars, those listed in the table. The preliminary work brought out several factors that made this reduction desirable from the point of view of amateur observers.

It became evident that the brightness of an Orion variable should be observed at least every two days, in order to obtain a satisfactory light curve. Furthermore, our first observations showed differences that could be either personal errors or very rapid minor fluctuations in the stars. To solve this problem, we made intensive observations during January, 1959, when 900 estimates were obtained.

This "crash program" showed that the Orion variables did have minor changes in less than a day, but that differences were still sometimes considerable. Therefore, Mr. Bell visited each of the other two observers, to make simultaneous estimates of the variables. The agreement among us was much better during this experiment. Other tests showed that differences among our telescopes did not affect this agreement.

Our experience indicated that the Orion variables should be observed nightly, and the more erratic stars two or three times a night. The time of each estimate should be recorded to the nearest minute.

The light curves we obtained can be divided into four classes: 1. Those with no major change during several days. 2. Those in which continuous small fluctuations occur. 3. Those with great changes in brightness in the course of a few days. 4. "Flare" curves, in which a short-lived increase in brightness is superimposed on a normal light curve.

All of the nebular variables appear to change back and forth among the first three of these classes, perhaps 80 per cent spending some time in the second class during a year. The spectacular large-amplitude curves are relatively rare.

During 1958-59 we found two stars to manifest flare characteristics, TU Orionis and MR Orionis. TU is known to have a *K*-type spectrum, normal for flare stars, but MR is a main-sequence *A*2 object. When the flare of MR occurred, it was recorded by two observers simultaneously, leaving little doubt of its reality.

The Orion variables offer many opportunities for useful work by amateurs. First, of course, is the need for more visual observations of brightness. A number of the stars listed in the table can be followed with telescopes as small as 3-inch, and practically all are observable in a 10-inch. Amateurs interested in systematic work along these lines are invited to communicate with the writer, whose address is 1411 Amapola St., Torrance, Calif.

An observer who has suitable photographic equipment could make a valuable contribution by exposing two plates, an hour apart, every two days. Such photographs would supply a needed check on the visual observations, and would serve as a flare patrol. This program should be carried out in yellow light to suppress the nebulosity, and to furnish magnitudes comparable to the visual ones: a 103a-D emulsion behind a Schott GG-11 filter is recommended.

POSITIONS AND VISUAL RANGES OF VARIABLES IN ORION NEBULA

Name	*R.A.* (1900 co-ordinates)	*Dec.* (1900 co-ordinates)	*Magnitude Max.*	*Min.*
EZ	05h 29m 23s	−05° 08′.9	11.2	12.6
IU	41	45.7	8.8	10.0
IX	46	26.7	12.6	13.8
IY	47	54.3	12.1	13.0
V372	53	38.3	7.8	8.5
KN	30 02	15.6	12.8	13.7
KO	02	35.6	13.0	14.0
KQ	03	27.9	12.3	13.5
KS	05	29.3	9.9	10.9
KZ	09	34.0	13.0	13.7
LL	05 30 11	−05 29.3	10.9	12.6
LP	15	31.9	8.0	9.4
V356	15	34.0	12.8	13.8
LQ	16	27.7	11.8	13.0
LR	16	30.3	11.9	13.2
LS	16	42.2	12.6	13.3
AA	16	50.5	12.3	13.7
LT	17	20.9	12.7	13.5
LU	17	30.0	12.0*	13.4
LV	18	27.7	12.1	13.3
LX	05 30 19	−05 43.5	11.9	13.1
BM*	21	27.1	8.1	8.8
MP	21	55.7	12.5	13.5
AE	22	25.5	12.3	?
MR	22	25.7	10.3	12.0
MS	23	20.6	12.8	13.5
MV	24	24.5	11.7	13.2
TU	25	24.9	11.6	?
MX	26	13.2	9.6	10.5
V358	29	34.7	11.9	12.4
AH	05 30 30	−05 13.8	12.2	13.9
NP	31	12.6	11.5	12.6
NQ	31	19.1	11.1	12.4
AI	32	15.1	12.0	14.2
AK	32	29.6	11.3	14.0
NU	36	20.0	6.5	7.3
V360	37	13.4	12.5	13.5
V361	37	29.2	7.8	9.6
NV	37	37.1	9.5	11.3
TV	41	05.2	12.9	15.1
NZ	05 30 43	−05 30.5	11.9	14.2
AN	47	32.1	10.5	12.1
T	56	32.5	9.4	12.2
AQ	57	32.7	13.0	14.2
AZ	31 22	15.5	12.2	13.1

*BM Orionis is an Algol-type star with a period of 6.47055 days.

McCrea's Theory of the Solar System's Origin

OTTO STRUVE, *National Radio Astronomy Observatory**

DURING the last two centuries, many scientists have attempted to explain how the sun and its family of planets came into being. In two of the earliest of these theories that amounted to more than mere speculation, Kant and Laplace suggested sun and planets were formed simultaneously by a single process — the gradual contraction of a gaseous nebula.

Around the year 1900, several theories were proposed in which the planetary system originated from a grazing collision between the sun and another star. Today, however, most astronomers once again feel that the formation of the solar system is closely connected with the processes that create stars.

One reason for this recent reversal of opinion is a fatal defect of all collision theories — these stellar encounters are much too rare. Our sun, for example, is more than four light-years from its nearest neighbor star, and with a relative velocity of 20 kilometers per second it would take roughly 10^5 years to travel that distance.

But the sun, as seen from a distance of four light-years, occupies only about 10^{-18} of the entire sky; the other star, as viewed from the sun, may be regarded as covering an equal area. Thus, the probability of the two objects striking one another after 100,000 years is only 2×10^{-14}. Even if we increase this value to allow for near misses, the probability of a particular star colliding with another during the entire past life of the galaxy (say five billion years) is only about 5×10^{-11}.

Since our galaxy contains roughly 2×10^{11} stars, perhaps only one or two collisions have taken place in it during the past five billion years. And if the sun had been one of the partners in such an encounter, our solar system would be practically unique. However, evidence from other solar-type stars seems to indicate that planetary systems are common in space. Collision theories, therefore, should be discarded.

This evidence comes from stellar rotation. Because of the Doppler effect, light from the approaching part of a rotating star is shifted toward shorter wave lengths, light from the receding portion to longer wave lengths, thereby widening all the lines in the spectrum. Thus, the rotational velocities for many stars can be determined from the broadening of their spectral lines.

EQUATORIAL VELOCITIES OF STELLAR ROTATIONS*

Rotations	*Percentage of Stars by Spectral Types*					
(km./sec.)	*Oe, Be*	*O, B*	*A*	*F0-F2*	*F5-F8*	*G, K, M*
0-50	0	21	22	30	80	100
50-100	0	51	24	50	20	0
100-150	0	20	22	15	0	0
150-200	1	6	22	4	0	0
200-250	3	2	9	1	0	0
250-300	18	0	1	0	0	0
300-500	78	0	0	0	0	0

*Adapted from C. W. Allen, *Astrophysical Quantities*, 1955, page 186.

A fact of great cosmogonical significance becomes apparent when we compare the rotations of stars of different spectral types. The table shows that most stars hotter than *F5* (surface temperature 6,500° absolute) are rotating rapidly, while cooler stars like the sun (as well as giants, long-period variables, and others) have slow rotations. Since other stellar characteristics, such as color and mass, fail to show any similarly abrupt change at *F5*, we must infer that some unobservable property accounts for this discontinuity.

To realize the significance of this property, consider what the solar rotational velocity would be if there were no planets. That is, suppose all of the angular momentum of the planets, from their orbital motion and rotation, were added to the sun's.

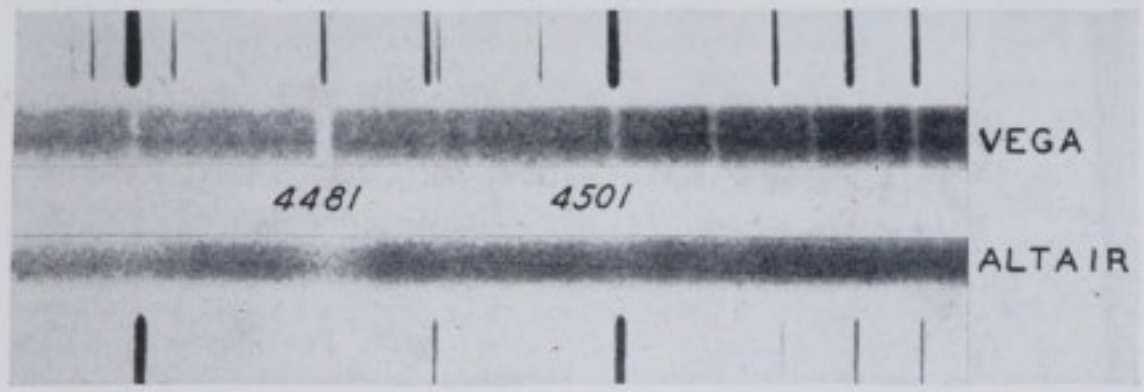
The orbital angular momentum, A, of a planet is the product of its mass, orbital velocity, and distance from the sun. For example, Jupiter has a mass of 2×10^{30} grams, and is traveling 1.3×10^6 centimeters per second, at an average distance of 7.8×10^{13} centimeters from the sun; the product of these quantities is $A = 1.9 \times 10^{50}$. This is practically the total angular momentum of Jupiter, as the planet's rotation contributes little.

Next, estimate the sun's angular momentum by assuming that a typical gram of solar material moves at a distance of 5×10^{10} centimeters from the sun's axis of rotation, with a velocity of 5×10^4 centimeters per second. Since the solar mass is 2×10^{33} grams, the result is 5×10^{48} — only about 1/40 of what we just found for Jupiter.

More refined calculations show that the total angular momentum of the solar system is 3×10^{50}. The planets contain 98 per cent of this, and the sun the remaining two per cent, even though the combined planetary masses are only 1/1,000 that of the sun. Thus, if all the present planets were combined with the sun, its rotational velocity — now two kilometers per second at its equator — would be increased by a factor of 50. Our star would then be spinning fairly rapidly, at 100 kilometers per second, like the hotter stars.

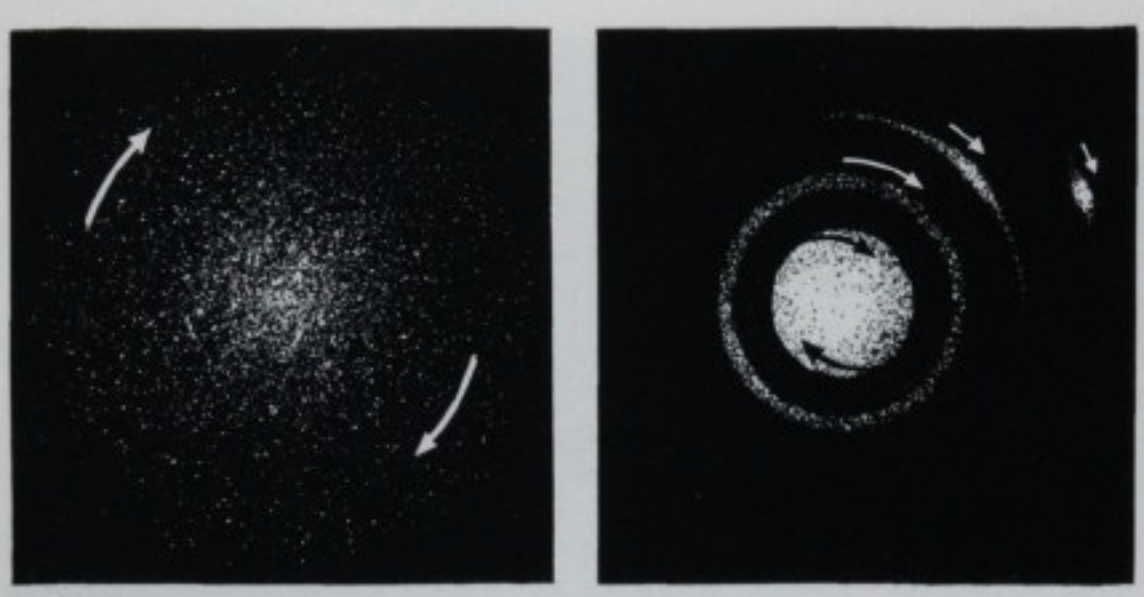
The small angular momentum of the sun and the large amount associated with the planets have constituted the principal stumbling block of earlier cosmogonical theories. Laplace's nebular hypothesis and several later modifications of it fail completely to account for this important property of the solar system.

Recent attempts have been made to explain the discrepancy. The Swedish astronomer H. Alfvén has suggested that the magnetic field of the sun, revolving with it, would tend to transfer momentum from the sun to a surrounding nebulosity. V. G. Fessenkov, in the U. S. S. R., has suggested that about five billion years



Matching portions of the spectra of Vega and Altair. These are both A-type stars, but Altair's lines are greatly broadened by rapid rotation. The effect is conspicuous for the magnesium line at 4481 angstroms; weaker lines, such as 4501, are widened to near invisibility. Yerkes Observatory photograph.

*Operated by the Associated Universities, Inc., under contract with the National Science Foundation.



P. S. Laplace's nebular hypothesis (1796) contained the germ of modern theories. He suggested that originally a large rotating nebula of hot gas cooled and shrank, spinning faster and faster. It was supposed to shed rings of gas that condensed into planets, the remainder forming the sun.

ago the sun may have been 10 times as massive as now, and that the excess mass was lost by corpuscular emission from the surface layers, thereby carrying off a large part of the original momentum. But neither of these explanations accounts for the sharp break in the stars' rotational velocities at spectral type *F5*.

Several recent studies by A. Sandage, A. Slettebak, G. Herbig, and others, lend support to our working hypothesis that the peculiar distribution of angular momentum among the sun and planets resulted from the manner in which the latter were formed. Many yellow *giant* stars of spectral types *F* to *G* have fairly rapid rotations. According to J. Oke and J. Greenstein, the star Xi Geminorum, with an *F5* spectrum and absolute magnitude +1.9, has an equatorial velocity near 73 kilometers per second, if its axis of rotation coincides with the plane of the sky. The value for an *F5* dwarf is much less than this.

But Xi Geminorum is an old star, which several billion years ago was a blue dwarf with a surface temperature of about 10,000° absolute and a radius only half of what it is now. Because of its smaller size when it was a dwarf, the rotation would have been twice as fast as now, or 146 kilometers per second — a perfectly reasonable value for an *A*-type dwarf.

Evidently, old stars that increase in size because they exhaust the hydrogen in their interiors preserve their original angular momenta. Their equatorial velocities decrease, but still remain larger than for dwarf stars of similar spectral class. Hence, we may conclude that the angular momentum of a star, with or without planets, remains reasonably constant, and is not seriously lessened by magnetic braking or other processes.

These points seem to indicate that all, or most, solar-type stars have low rotations and therefore possess planetary systems. It does not, however, tell us the mechanism by which the planets were formed, nor how any star, single or with planets, could have acquired as small an angular momentum as our sun's.

Most astronomers now believe that the sun and other stars originated in the gravitational contraction of large "cells" of interstellar gas and dust. We may visualize such a cell as a cloud perhaps four light-years in radius, with a mass roughly that of the sun. We shall assume that gravitationally stable condensations of gas *can* form, and that they grow more massive, at length becoming visible as black globules when seen in front of a bright nebula. How will this process lead to the formation of a solar system?

Nebulae that are typical birthplaces of stars show turbulent internal motions, of the order of five to 10 kilometers per second. These are chaotic movements, though sometimes in well-defined stream patterns. If a cell of such nebulosity, containing as much material as the sun, contracts from an original density of 10^{-22} gram per cubic centimeter to that of the sun, 1.4, the chaotic motions will never completely cancel out. Some angular momentum will remain, and this will be more than the solar system now has.

This difficulty can be overcome either by assuming that stars originate only in unusually quiescent regions of the interstellar medium, or by the mechanism W. H. McCrea has proposed in his new theory to explain the small angular momentum of the sun. McCrea, professor of mathematics at the University of London, presented his ideas at the 1959 Liége symposium on stellar evolution.

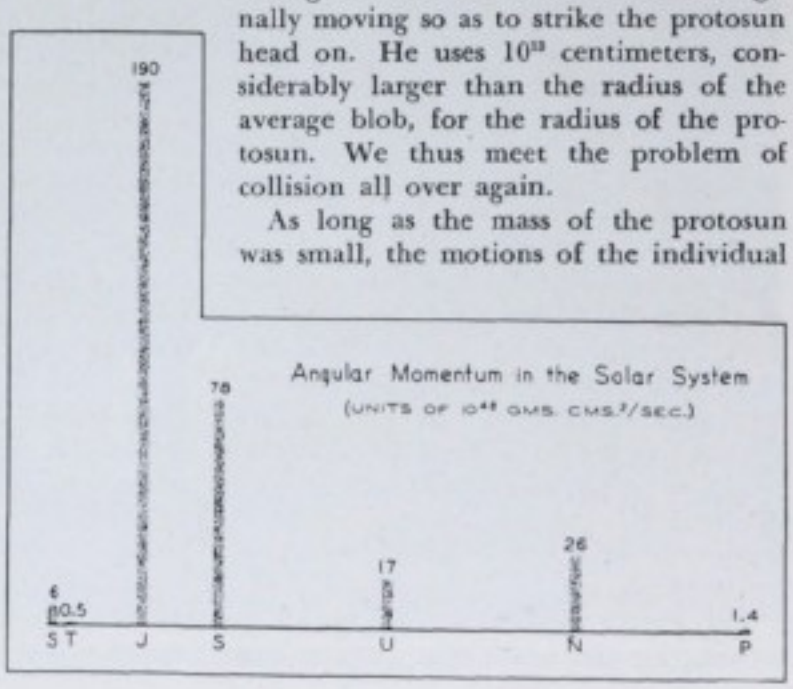
Let us assume, then, that the original cell from which the sun formed contracted until its main body was not much larger than the present distance of Pluto from the sun. Within this sphere of radius *(R)* 5×10^{14} centimeters (about 40 astronomical units), is a total mass *(M)* 2×10^{33} grams, equal to the sun's. Since the original material was not homogeneous, suppose the sphere contained *N* blobs of matter, moving with randomly directed velocities *(V)* of 10^4 centimeters per second. Such material would be cold, with a temperature of about 100° absolute.

McCrea has shown the most probable angular momentum of the sphere's contents equals $M V R / N^{\frac{1}{2}}$. Substituting the numerical values we have chosen, and equating this to the total angular momentum of the solar system (3×10^{50}), we find that *N* is 10^8. From this and the volume of the sphere, the centers of neighboring blobs would be about 2×10^{13} centimeters apart, on the average.

The distance that a blob would travel before collision with another is assumed by McCrea to be about *R*, for if it were smaller the blobs would interact. This means that, if *s* represents the radius of a blob, a cylindrical path of volume $4\pi s^2 R$ would contain just one blob, statistically speaking. This volume is also $1/N$ that of the sphere of radius *R*, from which $s = 10^{12}$ centimeters.

The original "protosun" was presumably an average blob that accidentally coalesced with one or two others, and thus began to act as a center of attraction for many more. However, had all the packets of matter within the sphere combined with the protosun, the sun's angular momentum would now be 3×10^{50}, and not a small fraction of this. Hence, McCrea suggests that the only blobs combining to make the sun were those originally moving so as to strike the protosun head on. He uses 10^{13} centimeters, considerably larger than the radius of the average blob, for the radius of the protosun. We thus meet the problem of collision all over again.

As long as the mass of the protosun was small, the motions of the individual



The principal planets have greatly differing shares of the total angular momentum of the solar system, as indicated by the approximate values in this chart. The contributions of the four terrestrial planets (Mercury, Venus, Earth, and Mars) are so small that only their sum is shown, labeled "T." Left of it is the sun's value.

This Lick Observatory photograph of the gaseous nebula Messier 8, in Sagittarius, was taken on July 12, 1939, by N. U. Mayall with the 36-inch Crossley reflector. Many patches of obscuring dust are seen in silhouette against the bright background, of which the very smallest round specks are known as globules. These are generally regarded as dense dust clouds in the process of condensing into stars, perhaps in many cases to be accompanied by planets.

blobs were practically rectilinear. Blobs that did not hit the target would ultimately move out of the sphere, but they would be replaced by an equal number, having the proper directions, coming from parts of the nebula outside the sphere. Thus, the total mass of the sun would eventually become practically equal to that in the sphere. However, because of the radial direction of their motions, these additional impacting blobs would bring in only very little more angular momentum to the protosun.

McCrea's calculations show that about four per cent of the angular momentum of the whole sphere would be taken up by the growing protosun. This is a very reasonable value — in good agreement with the fact that the sun now has two per cent of the total angular momentum of the solar system. The length of time required for the sun to accumulate N blobs is estimated by McCrea to be about 100,000 years.

This theory shows that it is possible to account for the small solar angular momentum and, by similar reasoning, for that of other cool stars. N blobs, some from within the sphere of radius R, others from outside, formed the sun. Not all the blobs coalesced with the protosun, for those within the sphere that had large angular momenta presumably formed the planets and satellites.

But could many of these packets of material actually unite to produce a single giant planet like Jupiter? In other words, would the force of attraction between two condensations in contact be large enough to resist separation by the sun's gravitation? This problem is answered by the criterion of tidal stability, discussed on page 349 of Sky and Telescope for June, 1956. Calculation shows that the blobs would coalesce to form a planet such as Jupiter, providing their radii are assumed to be slightly less than the rough value of 10^{12} centimeters we had derived.

More serious is the fact, pointed out by McCrea, that two blobs colliding head on with a velocity of one kilometer per second would generate so much heat that they would tend to evaporate. Probably, however, the relative velocity of two blobs moving around the protosun in approximately the same direction was much smaller than this value. Moreover, a head-on collision between two blobs was not necessary for them to combine, and there may have been dust particles or suitable molecules present that could rapidly radiate a large amount of heat.

The importance of the tidal-stability criterion in cosmogony was first clearly demonstrated by G. P. Kuiper, long before McCrea developed his theory. No attempt has yet been made to integrate the two theories, but it seems to me that they are entirely compatible.

CORRECTION

In the key drawing of the moon's far side on page 73 last month, the Sea of Dreams is not plotted, and the plain north of Tsiolkovsky is erroneously given this label. This mistake was pointed out by Jay H. Respler of New York City.

OBSERVING THE SATELLITES

Discoverers VII and VIII

ATTEMPTS to recover an elusive space capsule in mid-air failed again on two occasions last November. In the case of Discoverer VII, launched on November 7th at 20:28:41 Universal time, malfunction of an inverter in the electrical power supply interfered with the satellite's stabilizing system and its separation sequence. For Discoverer VIII, sent aloft on November 20th at 19:25:24 UT, the capsule was apparently separated, but an air-and-sea search failed to locate it.

Both the firings were from Vandenberg Air Force Base in California, with vehicles similar to those employed earlier in the Discoverer series. The initial boosters were 50-ton Thor missiles. The second stages weighed about 1,700 pounds, including the 300-pound re-entry capsules, which were about 33 inches in diameter and 27 inches long.

Radio signals from Discoverer VII showed that it was tumbling slowly, although this action did not prevent successful reception of telemetered information. Separation of the capsule was planned for its 17th revolution, so that Hawaii-based planes and ships might search for it during and after descent. However, the faulty inverter furnished insufficient power for the separation sequence, and the capsule remained attached to the satellite throughout its lifetime.

Discoverer VII, officially designated 1959κ, was tracked mainly through Doppler observations of its radio signals until November 21st, when its transmitter apparently went silent. Radar provided the only additional orbital information. According to Space Track, 1959κ traveled in an orbit inclined 81.64 degrees to the earth's equator. Initially its nodal period amounted to 94.55 minutes, perigee height 100 miles, and apogee 515 miles. This satellite fell to the earth on November 26th.

Recovery of the capsule from Discoverer VIII was attempted during its 15th revolution rather than the 17th, as originally scheduled, since the orbital period of 103.66 minutes brought this crossing closest to the selected recovery area, southeast of Hawaii. Telemetry indicated that the capsule separated on November 21st at 21:20 UT, and that the retro-rocket fired. However, there is no evidence that the parachute opened, and while several search planes reported receiving signals from the capsule's radio beacon, the hunt was unsuccessful.

For Discoverer VIII, the orbital inclination was 80.65 degrees, according to Space Track. Its initial apogee height of 1,040 miles, appreciably greater than that of any of the earlier Discoverers, gives a longer expected lifetime for 1959λ — more than three months, despite a relatively low perigee of 117 miles.

One consequence of this longer lifetime is the possibility of optical observations of Discoverer VIII. Although launched at midday, its subsequent crossings at any given latitude occur 8.1 minutes earlier daily, as measured by the local mean time at the subsatellite point. Thus, during the last few days of 1959 the satellite's southward crossings over the United States will occur earlier and earlier during morning twilight, and it will become visible against an increasingly dark sky.

More strikingly, however, the northward passages over United States latitudes during the evening hours early in 1960 will show Discoverer VIII illuminated near its perigee height at an hour when the sky is quite dark. 1959λ will then be readily visible to the unaided eye.

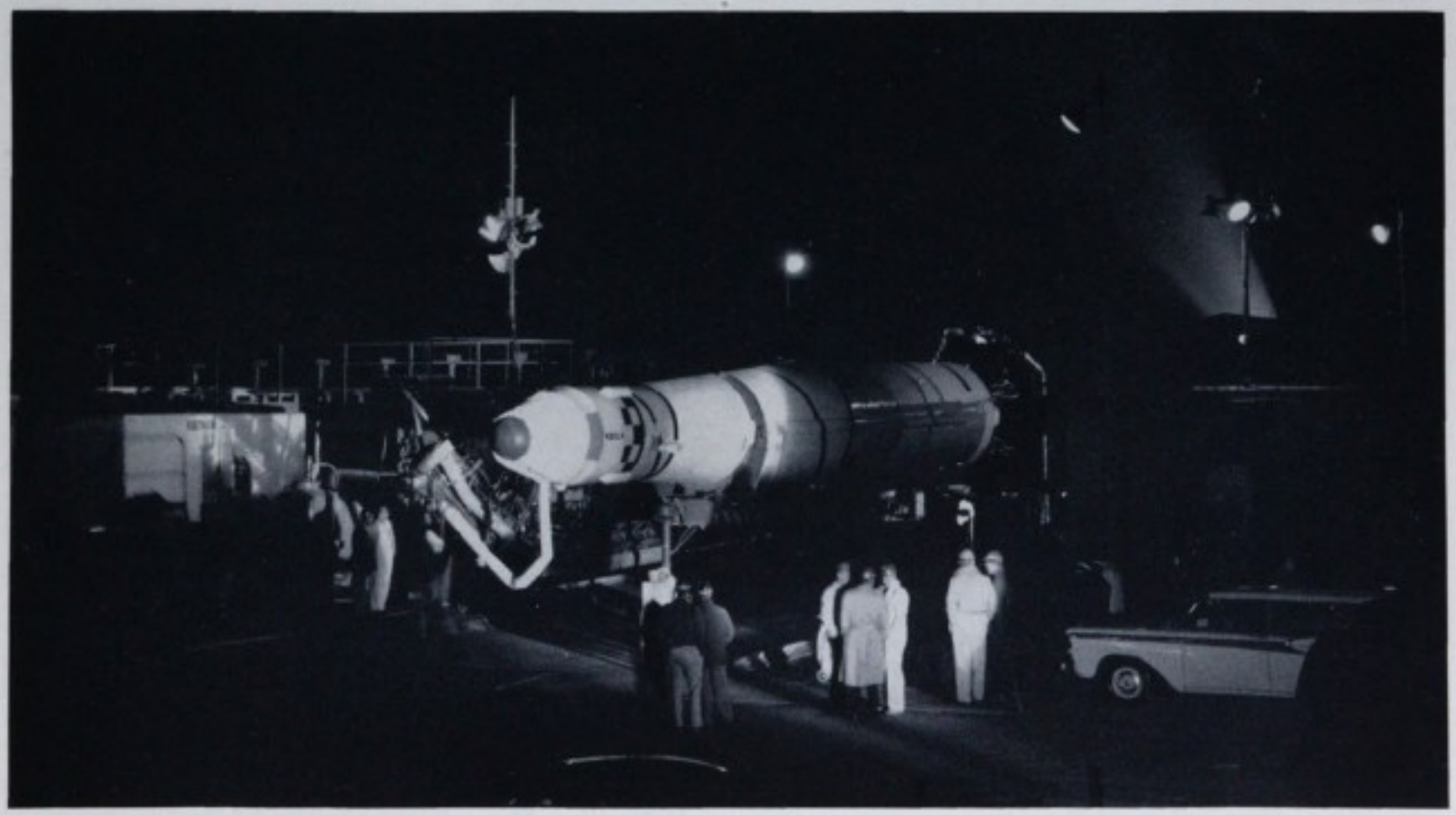
On the evening of January 4th, as the satellite passes northward over parallel +35°, the local mean time at a point directly beneath it will be about 6:13 p.m. Observers near this latitude ought to begin looking eastward 50 minutes earlier (about 5:23 p.m. local time). They should observe progressively closer to the celestial meridian as 6:13 approaches, afterward shifting their attention westward for another 50 minutes.

The satellite will pass sometime during the 100-minute interval, as this slightly exceeds one orbital period. For a more detailed search plan, the height above ground — roughly 115 miles — should be taken into consideration.

The same search on later dates may be made eight minutes earlier for each day after January 4th. Once a crossing has been observed, the times of subsequent ones become approximately known from the period of the satellite.

Explorer VI and Lunik III

BECAUSE their radio transmitters have ceased functioning, it is now difficult to track the two artificial satellites whose orbits reach out farthest from the earth



A two-stage Discoverer vehicle is being readied at Vandenberg Air Force Base, California. U.S. Air Force photograph.

Another photograph of the moon's far side. This large-scale picture, of superior quality, is one of the series that Lunik III took on October 7, 1959, between 3:30 and 4:10 Universal time, while the probe's distance from the moon was increasing from 65,200 to 68,400 kilometers. The moon's axis is indicated by the two short lines, south being below. According to Soviet tracking data, when this picture was taken the center of the moon's disk, as seen by Lunik III, was selenographic latitude +17°, longitude +117°. The dark area at the upper right is Moscow Sea; near the lower right, the compact black marking is the crater Tsiolkovsky. See the December issue, front cover and page 73, for the earlier photograph and for a key chart. The new picture has just been published in a 33-page Russian book, "First Photographs of the Reverse Side of the Moon," issued by the U. S. S. R. Academy of Sciences. It was made available by Prof. A. A. Mikhailov, Pulkovo Observatory.

into space. Explorer VI and Lunik III must therefore be tracked by optical means, although the former comes inside radar range at perigee, when its distance is about 150 miles.

Explorer VI is the paddle-wheel satellite, launched by the United States on August 7, 1959. Evidently one of its paddles locked improperly, reducing the useful output of the solar batteries carried on them. On October 6th, ground stations received the last transmitted data from the 15 experiments performed by this satellite. About a year will be needed to reduce the vast amount of information telemetered during the two months the radio functioned.

Lunik III is the history-making probe that photographed the far side of the moon on October 7th. Russian announcements of the end of its radio transmissions were made in mid-November, although tracking data provided by unofficial Soviet sources suggest that the signals may have ceased October 26th, about three weeks after launching. Collision with a tiny meteorite is a possible cause of transmitter failure.

Optical tracking of Lunik III is very difficult. Its unusual orbit (page 91, December issue) cannot be predicted far in advance, and it is extremely faint even at perigee. Within a day or two of its nearest passage to the earth on November 19th, at a distance of 29,000 miles, its predicted visual magnitude ranged from about 12 to fainter than 16.

As mentioned here in earlier issues, highly elongated orbits like those of Explorer VI and Lunik III are considerably influenced by the gravitational attractions of the moon and sun. In the case of the Russian satellite, 1959θ1, any accurate forecast of its motion requires step-by-step calculations. This problem was summarized at the Washington meeting of the American Rocket Society in November by Leonid I. Sedov, chairman of the Soviet Academy of Sciences' spaceflight commission and president of the International Astronautical Federation.

The orbital inclination of 1959θ1 will change markedly under the influence of the sun and moon. The inclination will vary from a value near 80 degrees during the first perigee passage to about 48 degrees on the 10th revolution. Then, on the 11th circuit, the moon's pull will increase this to about 57 degrees. Simultaneously, the perigee distance will diminish rapidly, and the 11th revolution at the end of March will be Lunik's final one. It is expected to enter the earth's atmosphere in the Northern Hemisphere.

Dr. Sedov also gave more data on the probe's encounter with the moon in early October. The total energy of the satellite, that is, the sum of its kinetic and potential energies with respect to the earth's center, increased almost nine per cent. More noteworthy, passage through the moon's strong gravitational field nearly tripled the angular momentum; projection of this momentum vector upon the earth's equatorial plane shows an almost complete reversal in direction.

The Russian scientist discussed the factors involved in selecting the launching date and time, and the trajectory of the moon probe. The October 4th anniversary of the first Sputnik two years ago happened to be a favorable time in 1959 to send out a satellite intended to photograph the other lunar hemisphere. Contrary to popular belief, choice of a launching day for such a mission is narrowly prescribed.

Among special considerations were that the sun properly illuminate the moon's far side, and that the moon be well south of the celestial equator, since the rocket was fired from the Northern Hemisphere. Some trajectories required more precise programming than others, and the payload depended on the choice of trajectory. The flight duration had to be such that radio antennas within the Soviet Union could receive signals at the time of close approach to the moon.

MARSHALL MELIN
Research Station for Satellite Observation
P. O. Box 4, Cambridge 38, Mass.

Amateur Astronomers

Ohio Students Build High School Observatory

ALMOST two years ago several students at the Worthington High School began planning an observatory. Their first concern was an instrument adequate for visual observing and a little research. Rick Orwig, who had some experience in grinding mirrors, was given the assignment of producing an 8-inch mirror; he also supplied the mirror cell, diagonal, and telescope tube.

Their next problem was a suitable site for their building. Our high school suggested that it be constructed on its 80-acre campus, and the boys quickly agreed. Ground was broken in June, 1958, and although inclement weather slowed progress, the double-brick walls of the observatory were finished early that fall. A commercial silo dome, 13 feet in diameter, was purchased and modified to have a slit and shutter.

As the school year drew to a close, extra effort was put into the project. At our annual community get-together, the first informal open house drew about 250 persons for a view through the 8-inch f/9 reflector. At present the observatory is being used by my science classes, and I am designing an electric sidereal drive sufficiently accurate for short time exposures.

Various fund-raising methods were used. On one occasion, the boys invited Dr. J. Allen Hynek, Smithsonian Astrophysical Observatory, to give a lecture for them. Whenever money became low, they washed automobiles on Saturdays.

Besides Mr. Orwig, the boys responsible for this project were Jeff Weed, Steve Bobrovnikoff, Sam Cushman, Ed Hopton, Don Brown, and Rod Garman. Robert Wise, president of a local ice-cream cone company, assisted them in the design and construction of the dome, and on the basic parts of the mounting. Earl Lane, their physics teacher, was in charge of the group last year. I took over his position when he was made assistant principal of the high school.

Visitors are always welcome to the observatory, and I shall be pleased to answer questions concerning the project.

MERRITT STEVENSON
Worthington High School
300 W. Granville Rd.
Worthington, Ohio

Foundation work is being done on the observatory for the Worthington High School by a group of students who volunteered to produce the installation. Most of the money for the building and its 8-inch reflector was raised by the boys. These photographs are from Merritt Stevenson.

MISS C. M. NOBLE DIES

Junior astronomy lost one of its most ardent supporters with the passing of Miss Charlie M. Noble last November 30th in Ft. Worth, Texas. She was 82 years old.

In 1956 Miss Noble was given the Astronomical League award at the Miami national meeting, the first woman to be so honored. The planetarium at the Ft. Worth Children's Museum was named for her.

During World War II she taught celestial navigation to naval officer trainees, after she had retired as head of a high school mathematics department.

Miss Noble began teaching astronomy at the Children's Museum in 1947. Among her innovations was awarding a certificate to youngsters who completed the course. She also set up a telescope-lending library.

MONTREAL, CANADA

A total of 672 individual observations were made during the year ending September 30, 1959, by the seven members of the naked-eye sunspot observing group of the Montreal Centre, Royal Astronomical Society of Canada. Using welder's glass for protection of their eyes, the seven made 1,082 sightings of sunspot groups. One observer saw 47 in 27 daily sessions in August, while another saw 36 groups on 19 days during March.

In the society newsletter *Skyward*, for November, 1959, it is also noted that 52 members participated in one or more of 16 observational programs, including the sunspot viewing. The total attendance at the center's observatory for the year was 2,060, the Saturday evening observing meetings drawing 1,158 persons.

MILWAUKEE, WISCONSIN

We at the Milwaukee Astronomical Society have an opportunity to establish classes in astronomy and telescope making at the Milwaukee Vocational School. But before the school will schedule classroom space and provide the equipment and instructors, we must present examples of successful classes of this kind that have

At the left is the nearly completed 13-foot observatory dome of Worthington High School in Ohio. Rick Orwig, at the right, was responsible for making the 8-inch mirror for the telescope.

A word from Ward . . .

REMEMBER WHEN?

I wonder how many of my friends who get "Sky and Telescope" can recall reading headlines such as these:

FRANKLIN D. ROOSEVELT RE-ELECTED PRESIDENT!

SUPREME COURT UPHOLDS WAGNER ACT!

CIVIL WAR ERUPTS IN SPAIN!

Do those headlines sound like ancient history? They ought to. They appeared in papers all over the world — 24 years ago. Yet the ink on those headlines was just about dry when Adirondack Radio first opened its doors for business. The year? You guessed it — 1936!

From that time to this, to my knowledge, Adirondack Radio never made a newspaper headline. But in our own way, we, too, have made a little history.

We set our hearts on building one of the soundest, most reliable ham and optical outlets to be found anywhere in the field of amateur, hi-fi, optical, and radio equipment. We increased our stock, our scope, and the lines we carry so that today the products of America's major companies can be found behind our doors. To serve our customers better, we added new test facilities, new personnel, increased our mail-order operations — and moved through a series of six different locations, each one larger than the previous one.

In only one major aspect have we failed to reach our goal: we just haven't seen as many of our friends and customers — in person — as we'd like to!

We're only five minutes from the New York State Thruway, you know — 30 miles west from Albany — 50 miles east of Utica — Exit 27. Won't you please drop in to say hello soon — real soon? We'll be looking for you. Thanks.

Ward J. Hinkle

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been conducted in other cities than ours.

Does any school, society, or individual have a syllabus that we can use for a guide? The information contained in such books as Allyn J. Thompson's *Making Your Own Telescope* is not in the proper form for us to sell the kind of program required by the school.

All suggestions and correspondence from SKY AND TELESCOPE readers will be gratefully received. We, in turn, will share our progress.

RALPH BRICHTA
2005 N. 48th St.
Milwaukee 8, Wis.

THIS MONTH'S PROGRAMS

Cleveland, Ohio: Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. January 15, Rev. H. F. Birkenhauer, S. J., John Carroll University, "Scientific Work in the Antarctic."

Dallas, Tex.: Texas Astronomical Society, 8 p.m., Health and Science Museum Planetarium. January 25, B. Connor and D. Bradbury, "The Moon."

Denver, Colo.: Denver Astronomical Society, 8 p.m., Museum of Natural History. January 22, Dr. L. W. Leroy, Colorado School of Mines, "The Geology of the Moon."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. January 6, Dr. William L. Donn, Brooklyn College, "A Theory of Ice Ages."

New York, N. Y.: Junior Astronomy Club, 8 p.m., Waverly building, New York University. January 15, Owen Gingerich, Harvard Observatory, "Pluto."

Philadelphia, Pa.: Rittenhouse Astronomical Society, 8 p.m., Franklin Institute. January 6, Dr. Fred Hoyle, Cambridge University, "The Origin of the Chemical Elements."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Department auditorium. January 9, Mrs. Jaylee M. Burley, National Aeronautics and Space Administration, "Trajectories to the Moon and Planets."

WESTERN AMATEURS TO MEET IN SAN JOSE

The 1960 convention of the Western Amateur Astronomers will be held at San Jose, California, August 25-27. A field trip to Lick Observatory is planned.

On August 23rd, preceding the WAA conclave, there will be a meeting of the Western Satellite Research Network. On the 24th, sessions are scheduled for the Association of Lunar and Planetary Observers and tentatively for the American Association of Variable Star Observers.

WASHINGTON, D. C.

Eight junior members of the National Capital Astronomers are the subjects of thumbnail sketches in the society's November, 1959, *Star Dust*. Under the heading, "In These Hands," the publication appraises its junior membership:

"The NCA has often, during the past years, had various erratic and spasmodic eruptions of active juniors. A group will flare up and then silently disappear. Interest in astronomy has, however, brought busy minds flocking to our doors for guidance. Juniors make up almost half of our group and are increasing much faster than the senior memberships."

A NEW ENGLAND OBSERVATORY

Thanks are due Gordon W. Smith, of Ancaster, Ontario, Canada, for his basic plans of the observatory dome pictured here. The description of Mr. Smith's observatory in this department for December, 1958, led David Trombly and myself to start our project.

The building is 10 by 12 feet, and sits on eight concrete-filled pillars, each eight inches in diameter. To support my 4-inch Unitron refractor, an 8-by-8-inch pier, 12 feet long, is embedded in four feet of concrete and extends up through the floor of the building without touching it.

I shall be pleased to answer any questions on the constructional details of this observatory.

ROBERT C. BOILARD
2 Brooklawn Rd.
Wilbraham, Mass.

The 7½-foot dome of Robert C. Boilard's observatory rotates on roller-skate wheels, and is turned by a handle opposite the slit. The hatch comes off as a unit. The sides of the building, which shelters a 4-inch refractor, are of plywood covered with masonite clapboard.

ON TAKING PHOTOGRAPHS WITH QUESTAR . . .

This picture of the moon is longer and wider than Questar's barrel. We have trimmed a grainless 8 x 10 print to fit this narrow space, but 16 x 20 enlargements with very little grain are practicable. Indeed, it is easy to hide Questar behind one of its own photographs.

Many people are astonished that such professional work can be done with our little 7-pound portable jewel of telescopes, whose aperture is only 89 mm. Hundreds of Questar owners use their versatile instruments in a variety of photographic ways. A recent and exotic use was the successful photographing of missile nose cones re-entering the atmosphere.

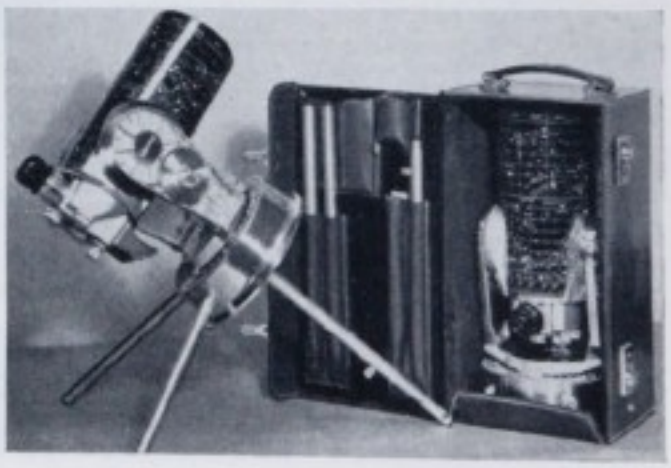
Questar's prime image of the moon is smaller than a dime, but this tiny image contains all the quality and detail that telescope and environment permit.

Taking pictures of the lunar disk can be a most rewarding avocation. However, it is no job for button pushers, for the "rules" keep changing, and the whole field is yours in which to try new ways to cut the losses inherent in the very process. Larger-scale negatives lose less in enlarging, so perhaps the best photographic resolution with the inexpensive 35-mm. film, as many Questar owners are discovering, is that obtained by means of eyepiece projection, which is described and illustrated in the Questar booklet published first in October '58.

A typical set of exposures by this method is shown in actual size above — note the variation in time and density. By thus using only part of the tiny prime-focus image and spreading it out over the whole film, excellent detail is captured even with exposures of as much as 15 seconds duration. Here Questar's relatively huge driving wheel (nearly half as big as the tube is long) insures perfect following. Questar's safety clutches are set lightly, too, so the movement will not falter from excessive friction. The operator must balance his camera load by some simple means, often by just weighting and adjusting the star chart, and try to shoot near the zenith where the seeing is always best.

Space forbids discussion of the many avenues one may explore. Much information is in our booklet, which also lists the several single-lens reflex-camera bodies that can be used with Questar. We will be very pleased to send you a copy without obligation. Questar still sells complete with fitted case for only $995 postpaid.

Questar New Hope Pennsylvania



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Also star projector and constellation projector (each approx. 4½" high). Projectors show many great constellations and stars, outline forms of Big Bear, Sagittarius, Southern Cross and others, for easy identification.

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TELESCOPE ROLL-FILM CAMERA

This model uses rolls of #127 film. Picture area will be a circle 1-9/16" in diameter.

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Stock #70,182-Y.....$29.50 ppd.

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Uses sheet film 2¼" x 3¼" size. Camera box size is 3" x 4" x 5".

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Gov't. Cost $75 — Price $14.95 ppd.

Determines positions of stars quickly. Shows various celestial co-ordinates. An extremely useful star finder which can be rotated through 60° angles along calibrated degree scale. Has single eye lens with viewing stop, two spirit levels for aligning, tangent screw with scale for fine precision readings, azimuth scale graduated in two-degree intervals, adjustable tilting azimuth scale for angle reference of stars on distant objects. War surplus. Gov't. cost $75.00. Instructions, carrying case included.

Stock #70,200-Y.....Only $14.95 ppd.

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Has crosshairs for exact locating. You focus by sliding objective mount in and out. Base fits any diameter tube — an important advantage. Has 3 centering screws for aligning with main telescope. 20-mm.-diameter objective. Weighs less than ½ pound.

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PRISM STAR DIAGONAL

For comfortable viewing of the stars near the zenith or high overhead with refracting telescopes using standard size (1¼" O.D.) eyepieces, or you can make an adapter for substandard refractors. Contains an excellent high-quality aluminized right-angle prism. The tubes are satin chrome-plated brass. Body is black wrinkle cast aluminum. Optical path of the system is about 3½".

Stock #70,077-Y.....$12.00 ppd.

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Stock #85,059-Y . . $39.50 f.o.b. Utah

Same as above, but new. Weight 25 lbs.
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f/8, 40" f.l., no mount or shutter. Weight 6½ lbs.
Stock #70,186-Y . . . . . $49.50 ppd.

f/5.6, 20" f.l., telephoto with shutter and diaphragm. Weight 6½ lbs.
Stock #70,187-Y . . . . . $65.00 ppd.

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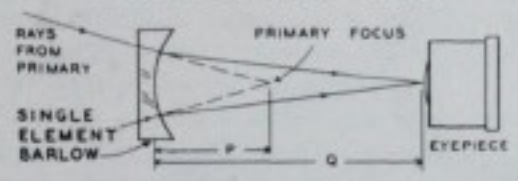
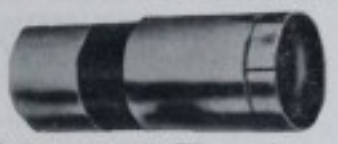
Stock #70,189-Y . . . . . $24.50 ppd.

These lenses are being successfully used for wide-aperture Moonwatch telescopes to see the small and fainter satellites. For eyepiece use our GIANT ERFLE.

DOUBLE AND TRIPLE YOUR TELESCOPE'S POWER WITH A BARLOW LENS



WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q.



Beautiful chrome mount. We now have our Barlow lens mounted in chrome-plated brass tubing, with special spacer rings that enable you easily to vary the power by sliding split rings out one end and placing them in other end. Comes to you ready to use. Just slide our mounted lens into your 1¼" I.D. tubing, then slide your 1¼" O.D. eyepieces into our chrome-plated tubing. Two pieces provided, one for regular focal length eyepieces and one for short focal length ones.
Stock #30,200-Y . . Mounted Barlow lens . . . . **$8.00 ppd.**

UNMOUNTED 3X BARLOW LENS

These lenses are made for telescopes that have smaller diameter eyepieces than the standard 1¼" size. Mount one between the eyepiece and objective, and triple your power. Instructions included. Single-element lens, focal length −1-5/16", unmounted.
Stock #30,185-Y . . . . 0.932" diam. . . . . **$3.50 ppd.**
Stock #30,328-Y . . . . 0.912" diam. . . . . **$2.50 ppd.**

3X ADJUSTABLE-DIAMETER BARLOW LENS

For telescopes with eyepieces smaller than the standard 1¼" outer-diameter size. Prongs on mount can be opened or closed to fit tubes from 1 5/16" to 1" outer diameter. Directions for using included.
Stock #30,339-Y **$5.00 ppd.**

8" SETTING-CIRCLE SET

Stock #50,133-Y . . Complete set . . . . . **$3.00 ppd.**
Stock #60,078-Y . . 360° declination circle only **$1.60 ppd.**
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5¾" SETTING-CIRCLE SET

Stock #50,190-Y . . Complete set . . . . . **$2.50 ppd.**
Stock #60,080-Y . . 360° declination circle only **$1.35 ppd.**
Stock #60,081-Y . . 24-hour right-ascension circle only **$1.35 ppd.**

SPECIAL SALE OF OPTICAL PERISCOPES

We made a lucky buy, so here is another famous Edmund war-surplus bargain. It is a $500.00 tank periscope with over $200.00 worth of optics in it for only $18.00 postpaid. At one spot, you look through and see up and out of the prisms at unit power; or you can look through the built-in telescope system and see a wide-angle view at 6x. Simply remove the top prism and you have an 11°.3 6-power satellite telescope. *Brand new in original packages.* Over-all size is 14" long by 7" wide by 2½" deep.

Now just for the bit of work involved in disassembling, you get a treasure-trove of precision optical parts for only $18.00. Glance at this list of parts and you'll realize what a value we are offering. You get a wide-angle Erfle eyepiece with a full 68° field and 1¼" focal length. This is the same eyepiece used in Moonwatch telescopes, our Stock No. 5160. Also included are a 38-mm.-diam. collimator lens, 131-mm. focal length; 48-mm.-diam., mounted, coated objective lens, 189-mm. f.l.; prism cluster containing two light flint glass right-angle prisms (A, 41 mm.; B, 91 mm.; C, 64 mm.; and A, 41 mm.; B, 57 mm.; C, 40 mm.); two mounted right-angle prisms (A, 23 mm.; B, 34 mm.; C, 23 mm.; and A, 40 mm.; B, 42 mm.; C, 30 mm.); two silvered tank prisms (A, 102 mm.; B, 53 mm.; C, 38 mm.; and A, 167 mm.; B, 69 mm.; C, 49 mm.). (*See our catalog for explanation of these prism sizes.*) Also some other optical elements and reticles. Every amateur will find this a real value. Don't wait — order today. The last time we had these they sold for $30.00 — now on sale at only $18.00.

Stock #70,227-Y . . . . . **$18.00 ppd.**

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Heavy-duty mount. Drive operates on 110-volt, 60-cycle, a.c. house current. Follows motion of stars smoothly. 32" tripod legs included.
Stock #85,081-Y . . . . **$76.50** f.o.b. Barrington, N. J.

Same mount as above, without clock drive, for 8" or smaller reflectors and for 4" or smaller refractors.
Stock #85,023-Y . . . . New Low Price . . . . . **$39.50** f.o.b. Barrington, N. J.

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$200 Gov't. Cost—Only $13.50

Big 2" objective, focusing eyepiece 28-mm. focal length, Amici erecting system, turret-mounted filters of clear, red, amber, and neutral, reticle illumination. Sparkling, clear, bright image — 6° field (325 ft. at 1,000 yards). Focus adjusts 15 ft. to infinity. Eyepiece alone, 28-mm. focal length, is worth more than $12.50.
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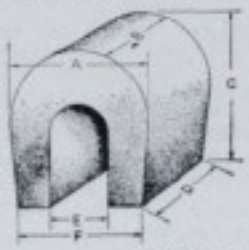

War Surplus — Alnico V type. Horseshoe shape. Tremendous lifting power. 5 lb. size. Its dimensions: A — 3¼"; B — 2⅝"; C — 4-3/16"; D — 1¼"; E — 1¾"; F — 2⅝". Strength is about 2,000 gauss. Will lift over 125 lbs.
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15¼-lb. size magnet. Approximately 5,000-6,000-gauss rating. Will lift over 250 lbs.
Stock #85,088-Y . . . . . **$22.50** f.o.b. Barrington, N. J.
Shipping wt. 22 lbs.

Mounted Ramsden Eyepieces

Standard 1¼" Diameter

Our economy model, standard-size (1¼" O.D.) eyepiece. We mounted two excellent quality plano-convex lenses in black anodized aluminum barrels instead of chrome-plated brass to save you money. The clear image you get with these will surprise you. Directions for using short focal length eyepieces are included with both the ¼" and ½" models.
Stock #30,204-Y . . . . ¼" focal length . . . . . **$4.75 ppd.**
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"MAKE-YOUR-OWN" 4¼" MIRROR KIT

The same fine mirror as used in our telescopes, polished and aluminized, lenses for eyepieces, and diagonal. No metal parts.
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Here is an exciting bargain. We obtained a large lot of these eyepieces reasonably — so down goes the price to $9.95. Lens system contains 3 coated achromats over 2" in diameter. Gov't. cost over $100.00. Brand new, weight 2 pounds. The value will double when this lot is all sold, and triple and quadruple as years pass. Their wide apparent field is 65°. The focal length is 1½". Lenses are in a metal cell with spiral threads; focusing adapter with 32 threads per inch is included; diameter is 2-11/16". You can make some super-duper finders with these eyepieces. They are also ideal for rich-field telescopes, which are becoming more popular daily, particularly in the space age.
Stock #50,178-Y . . . . . **$9.95 ppd.**

Attention! For Beginners, Junior Astronomy Clubs, Boy and Girl Scouts, Camp Groups, School Science Clubs

MAKE 8-POWER ASTRONOMICAL TELESCOPE with Low-Cost Beginner's Kit!

Every boy and girl of today dreams of being a part of the exploration of outer space. That desire makes building his own telescope a real thrill. Now anyone of Cub Scout or Brownie age on up can make his own astronomical 8-power telescope in one evening, without tools or machinery. Here is an ideal, attractive group project for scouts, junior astronomy clubs, or similar groups. (See special quantity prices.) Scope is powerful enough to show craters of the moon, Jupiter's satellites, and many stars not visible to the naked eye. Kit includes objective lens, field lens, eye lens, glare stops, kraftboard tubes, cadmium-plated metal ferrules, and other parts to build an 18"-long, 1¾"-diameter telescope of 8 power.
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Complete with Dyn-O-Matic Electric Drive and All Features Pictured and Described on This Page

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This new addition to the Dynascope line has won immediate recognition from schools, colleges, amateurs and professionals, as an outstanding achievement in a 6-inch telescope. Here is large aperture in a quality instrument which sells for a price that compares with many 4-inch telescopes.

You will find that this fine new portable 6-inch offers every feature necessary for serious astronomical viewing. The superb optical system resolves difficult objects with definition that is absolutely startling. The close tolerances of the precision construction assure an accuracy and smoothness of operation once associated only with the finest custom models. The heavy-duty mount, complete with electric drive, provides the stability so essential for satisfactory viewing, yet there is easy portability because in a matter of minutes the entire telescope can be dismantled into three easy-to-handle sections.

Only Criterion's engineering ingenuity, coupled with volume production and modern manufacturing methods, makes this handsome 6-inch model available at such reasonable cost. You can order it with complete confidence that it will live up to your expectations in every way, for this assurance is *guaranteed* under our full-refund warranty. Send your check or money order today. Or use our liberal time-payment plan and take months to pay.

You Could Pay $100 More Without Getting All These Superior Features (Except on Another Dynascope)

1. **EXQUISITE OPTICAL SYSTEM INCLUDES F/8 6-INCH PARABOLIC PYREX MIRROR** accurate to better than ⅛ wave, zircon-quartz coated. Teamed with elliptical diagonal, mounted in 4-vane adjustable spider.

2. **NEW DYN-O-MATIC ELECTRIC DRIVE** with smooth self-acting clutch that engages and disengages automatically as you seek different objects. Will not interfere when manual operation is desired. Entire drive housed in trim aluminum case. Plugs into ordinary household socket.

3. **CHOICE OF ANY 3 EYEPIECES** from the following: **65X**-18-mm. Achromatic Ramsden; **100X**-12.7-mm. Achromatic Ramsden; **150X**-9-mm. Achromatic Ramsden; **220X**-6-mm. Orthoscopic; **320X**-4-mm. Orthoscopic. All are precision-threaded, give sharp images to extreme edges.

4. **SOLID NEW EQUATORIAL MOUNT** extra-reinforced design to provide pillarlike stability. No annoying side play or wobble. Adjusts easily to any latitude.

5. **SETTING CIRCLES** for both right ascension and declination. Accurate to 0.0001 inch. Handsomely finished in fine aluminum.

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9. **BRASS RACK-AND-PINION EYEPIECE HOLDER** has precision-cut worm and gear for easier, smoother, more positive focusing. Takes standard 1¼" oculars, negative or positive.

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OBSERVER'S PAGE

Universal time (UT) is used unless otherwise noted.

Observing the Moon — Bessel

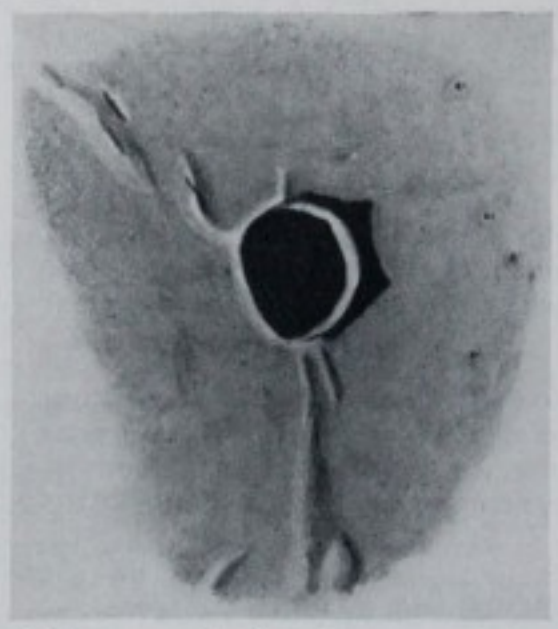
Of the major lunar seas, Mare Serenitatis is noteworthy for the scarcity of sizable craters inside its borders. Bessel is the largest; although only 10 miles in diameter, it is conspicuous because of its comparative isolation.

Bessel is somewhat irregular in shape, with a rounded interior depressed considerably below the level of the surrounding plain. While there is some disagreement between measurements by different observers, it appears that the west and east walls rise to heights of about 4,700 and 4,500 feet, respectively, above the floor. The western rampart reaches some 2,000 feet above the mare surface.

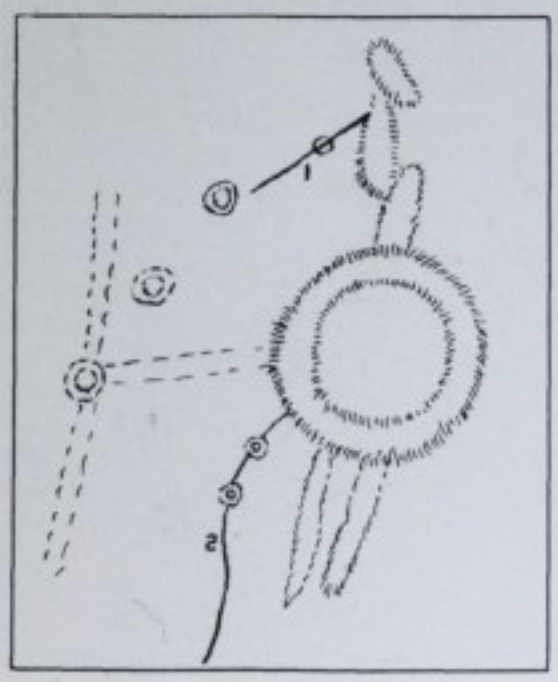
On the eastern wall are two minor elevations that cast the curious two-pronged outer shadow seen soon after sunrise. This appearance was first recorded by J. H. Schröter in 1794, and by many others since then; it is clearly shown in my drawing. According to J. Ashbrook's determinations, these two small peaks are about 340 feet higher than the saddle between them. My approximations are in good agreement with his figure.

There is little interior detail in Bessel. T. W. Webb once reported a central hill, but this has not been confirmed and it now seems certain that he was mistaken. P. Fauth detected two slight interior projections from the north and south walls, and saw several delicate clefts upon the floor, concentric with the wall. These details are not easily seen in instruments of ordinary size. Perhaps the most conspicuous feature is the low terrace at the foot of the inner east wall.

Bessel is situated astride one of the long, low ridges that cross Mare Serenitatis in a generally north-south direction. This ridge originates near the center of the sea, runs southward to the crater, and there makes a sharp bend to the southwest, continuing to near Promontorium Acherusia. Associations of this kind — between ridges and craters — are more



The crater Bessel and its associated ridges, as drawn by Alika K. Herring with a 12½-inch reflector, 236x eyepiece. Shortly before this time, 4:10 UT on May 14, 1959, the sun had risen on this part of the moon.



H. P. Wilkins made this sketch of Bessel on April 19, 1953, with the 33-inch refractor of Meudon Observatory. Note the delicate clefts numbered 1 and 2 by him.

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MIRROR CELLS — Light sturdy aluminum. Spring-adjusted to absorb shocks. Cut away for ventilation. **6", $7.00; 8", $11.50; 10", $35.00; ppd.**

ELLIPTICAL DIAGONAL HOLDER — Accurately machined from solid brass to fit 1¼" minor-axis elliptical diagonal. Fully adjustable for rotational and longitudinal movement. **$10.00 ppd.**

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Plate glass — With this material, probably anything better than about 1/8-wave surface accuracy is meaningless in use, considering the large expansion coefficient of plate glass.

Pyrex — 1/20 wave, or perhaps somewhat better, is meaningful here, since to a considerable extent pyrex will stand some temperature variation in observing use. 1/40 wave or better *can* be achieved in the laboratory under careful temperature control, but this means little in the field use of pyrex.

Fused quartz — Here is an entirely different matter, and 1/40 wave or better means something, even under field conditions, assuming no *drastic* temperature changes occur within a short period. I will be glad to quote on telescope mirrors of much higher than 1/20-wave precision, but *only* in fused quartz, where it is meaningful because of its very low coefficient of expansion.

NEW 1/20-WAVE PYREX MIRRORS, with 1/10-wave diagonal

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numerous than coincidence would provide, in my belief. Interested observers may note for themselves many cases where small craters lie atop or near mare ridges, particularly where pronounced changes in direction occur.

A curious Bessel phenomenon is the apparent displacement of the bright streak that extends across the crater. This ray seems to originate at Menelaus. Soon after sunrise, the part of the ray north of Bessel appears almost exactly aligned with the center of this crater. As the lunation progresses, the ray shifts toward the east until, by the time the terminator has reached Cassini, the ray is aligned with the east rim of Bessel. This pronounced displacement can be observed with ease in even small telescopes. The phenomenon is easily explained by the ridge, described above, which underlies the ray. Since the surface is not level, whatever portion of the ridge slopes toward the changing sun will appear brighter.

ALIKA K. HERRING
1312 Arlington Ave.
Anaheim, Calif.

A LATE-NOVEMBER AURORA

NOT for many years have the northern lights been seen at Houston, Texas, only 30 degrees north of the equator. Yet a red aurora was seen there by a team of eight amateurs who had set up a meteor observing station 20 miles northwest of Houston, on the occasion of a world night of the IGY-IGC meteor program, November 27-28, 1959.

Dennis Milon, Tim Fitzgerald, and six other present or former members of the Lamar Astronomy Club first saw the auroral display at 11:50 p.m. Central standard time. It was a reddish glow along the northern horizon. Ten minutes later the lights were at their strongest, white rays climbing to 20 or 25 degrees. The aurora brightened and faded until 12:45, when it disappeared completely.

Another Southwest observer, Raymond Schmidt, Winston, New Mexico, saw the display at about the same time. He describes it as a "rusty red glow." At Denver, Colorado, the reddish glow was first seen out of the back of an automobile by John Campbell, who was going home from a meeting of the Denver Astronomical Society. At 11:00 p.m. MST greenish yellow and red dominated the display, which lasted about half an hour.

Farther north, at Rapid City, South Dakota, Byron E. Painter saw rays in spite of heavy clouds to the north, beginning early in the evening, at 9:00 MST. Maximum brilliance was at 10 o'clock, the aurora later fading gradually.

Some 1,200 miles north of Houston, at Detroit Lakes, Minnesota, the aurora was also observed as very brilliant by Gregory Lamb, with the temperature −7° Fahrenheit. The display began about 11:40 CST, and by 11:49 the red and green corona was so strong it blotted out the Pleiades.

DEEP-SKY WONDERS

MANY an amateur has turned his telescope on brilliant Sirius on a crystal-clear cold winter evening, and watched the amazing procession of colors — reds, greens, violet-blues — as the mighty star twinkled in the heavy mantle of frigid air. Few, though, take the time to drop their finder four degrees below Sirius and wait for M41 to creep into the field of view.

Yet this is a pleasant experience. In contrast to Sirius, the field below is dark and vacant, allowing the eye to regain some of its sensitivity. After a minute or two this mighty galactic cluster rides into view. It is large — about the size of the full moon — and there seem to be many more than the 50 stars usually assigned to it. My best views of it have been with my 10-inch reflector, which does better justice to this cluster than even a 6-inch rich-field telescope.

For those who use charts and circles, M41 is NGC 2287, at right ascension $6^h\ 44^m.9$, declination $-20°\ 42'$ (1950 coordinates). Its total magnitude seems about 5, as I see it more readily than 6th-magnitude M11. The amateur can try to estimate the visual magnitude of this cluster by comparison with surrounding stars, with the aid of binoculars racked far out of focus.

Because of its declination, observers in southern latitudes should see much more than an amateur in New York, for example. Photographs of M41 are not commonplace.

Many visual observers speak of seeing curved lines of stars in M41. Although they seem inconspicuous on photographs, the curves stand out strongly in my 10-inch, and the bright red star near the center of the cluster is prominent.

The writer wishes to thank the many amateurs who write enclosing their observations of the objects discussed here. The mail is too heavy to acknowledge each report individually, but they are all recorded and help shape the content and tone of this column. Without them, Deep-Sky Wonders would be handicapped.

WALTER SCOTT HOUSTON
Rte. 3, Manhattan, Kans.

SIDEREAL TIME FOR 1960

THE VALUE of sidereal time corresponding to the solar time on a particular date differs somewhat from year to year, and therefore must be taken from a current almanac. As explained in the January, 1959, issue on page 144, the local sidereal time may be found from the formula:

$$\text{LST} = \text{GST} + A + \text{Local Time} + B.$$

Here LST is the local sidereal time, GST is the sidereal time on the Greenwich meridian at 0^h Universal time, A depends on the observer's longitude, and B converts the interval elapsed since 0^h local time from mean to sidereal time.

The table of Greenwich time on page 172 is from the *American Ephemeris* for 1960, rounded to tenths of a minute. Since the intervals are 10 days, it is easy to

The open star cluster Messier 41 in Canis Major, photographed by the 48-inch Schmidt camera at Palomar Observatory. South is above. The very bright star toward the upper right is 12 Canis Majoris, magnitude 6.0. The "New General Catalogue" description of M41 is: very large, bright cluster; little concentrated; stars of magnitude 8 and fainter.

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interpolate for other dates, the daily change averaging about 3.94 minutes. Corrections *A* and *B* may be found in the table below.

CORRECTION TABLE FOR SIDEREAL TIME

0:00	0.0	8:14	1.4	16:45	2.8
0:19	0.1	8:50	1.5	17:21	2.9
0:55	0.2	9:27	1.6	17:58	3.0
1:32	0.3	10:03	1.7	18:34	3.1
2:08	0.4	10:40	1.8	19:11	3.2
2:45	0.5	11:16	1.9	19:48	3.3
3:21	0.6	11:53	2.0	20:24	3.4
3:58	0.7	12:29	2.1	21:01	3.5
4:34	0.8	13:06	2.2	21:37	3.6
5:11	0.9	13:42	2.3	22:14	3.7
5:47	1.0	14:19	2.4	22:50	3.8
6:24	1.1	14:55	2.5	23:27	3.9
7:01	1.2	15:32	2.6	23:59	
7:37	1.3	16:08	2.7		
8:14		16:45			

NOTE: If the mean time interval with which this table is entered is one of the tabulated values, use the larger correction.

As an example, suppose that for January 24, 1960, we wish to calculate the local sidereal time corresponding to 10:46 p.m. Central standard time (six hours slow of UT) at a station in west longitude $6^h\ 15^m$ (93° 45′ west).

January 22nd is the nearest date in the table, giving the GST for 0^h UT as 8:01.4. To this add 2 × 3.94 or 7.9, to bring the date to the 24th, obtaining 8:09.3. This is the quantity GST in the formula.

Next, *A* is constant for any given station and is negative for east longitudes. The correction table shows that *A* is +1.0 minute for a longitude difference of 6:15.

Since our assumed station is 15 minutes west of the standard meridian, Local Time will correspond to 10:46 − 0:15 = 10:31, or 22:31 in 24-hour reckoning. If the station were east, then the difference in longitude between it and the meridian would be added to the standard time. Corrections for many cities are given on page 165.

The value of *B* for the time elapsed since 0^h local time, in this case 22:31, is read from the same table as 3.7 minutes.

Substituting these values in the formula gives for the local sidereal time

8:09.3 + 1.0 + 22:31.0 + 3.7 = 30:45.0,

or 6:45.0 when the excess 24 hours are discarded.

GREENWICH SIDEREAL TIME AT 0^h UT − 1960

Jan.	2	6:42.6	June	30	18:32.2
	12	7:22.0	July	10	19:11.7
	22	8:01.4		20	19:51.1
Feb.	1	8:40.9		30	20:30.5
	11	9:20.3	Aug.	9	21:09.9
	21	9:59.7		19	21:49.4
Mar.	2	10:39.1		29	22:28.8
	12	11:18.6	Sept.	8	23:08.2
	22	11:58.0		18	23:47.6
Apr.	1	12:37.4		28	0:27.1
	11	13:16.8	Oct.	8	1:06.5
	21	13:56.3		18	1:45.9
May	1	14:35.7		28	2:25.4
	11	15:15.1	Nov.	7	3:04.8
	21	15:54.5		17	3:44.2
	31	16:34.0		27	4:23.6
June	10	17:13.4	Dec.	7	5:03.1
	20	17:52.8		17	5:42.5
	30	18:32.2		27	6:21.9

SUNSPOT NUMBERS

The following American sunspot numbers for October, 1959, have been derived by Dr. Sarah J. Hill, Whitin Observatory, Wellesley College, from AAVSO Solar Division observations.

October 1, 60; **2,** 87; **3,** 96; **4,** 108; **5,** 111; **6,** 106; **7,** 120; **8,** 93; **9,** 82; **10,** 82; **11,** 99; **12,** 89; **13,** 83; **14,** 88; **15,** 108; **16,** 119; **17,** 126; **18,** 108; **19,** 110; **20,** 105; **21,** 97; **22,** 131; **23,** 164; **24,** 164; **25,** 150; **26,** 126; **27,** 158; **28,** 113; **29,** 134; **30,** 126; **31,** 151. Mean for October, 112.7.

Below are provisional mean relative sunspot numbers for November, 1959, by Dr. M. Waldmeier, director of Zurich Observatory, from observations there and at its stations in Locarno and Arosa.

November 1, 124; **2,** 121; **3,** 97; **4,** 93; **5,** 74; **6,** 74; **7,** 114; **8,** 122; **9,** 127; **10,** 131; **11,** 144; **12,** 151; **13,** 149; **14,** 134; **15,** 123; **16,** 109; **17,** 72; **18,** 56; **19,** 59; **20,** 65; **21,** 70; **22,** 110; **23,** 131; **24,** 147; **25,** 149; **26,** 149; **27,** 145; **28,** 117; **29,** 123; **30,** 135. Mean for November, 113.8.

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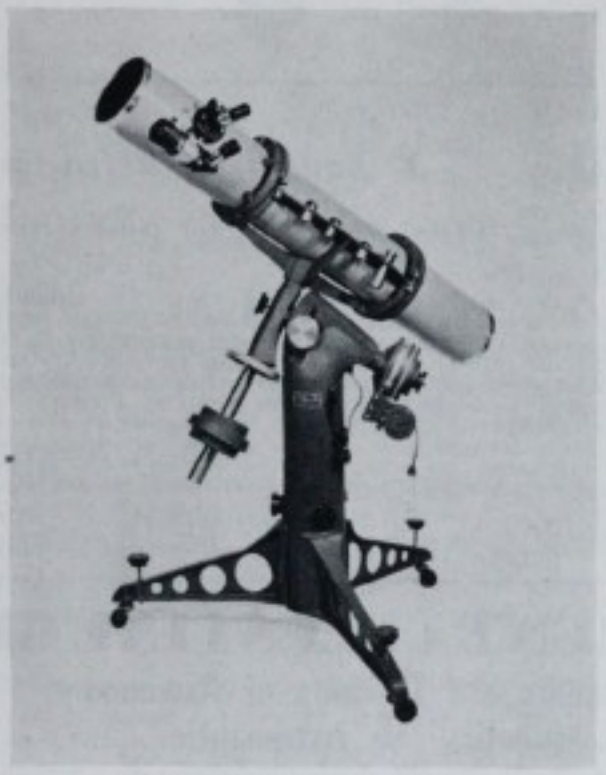

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BOOKS AND THE SKY

PARIS SYMPOSIUM ON RADIO ASTRONOMY

Ronald N. Bracewell, editor. Stanford University Press, Stanford, California, 1959. 612 pages. $15.00.

ASTRONOMY'S sudden expansion is nowhere so evident as in the field of radio astronomy. This is forcefully illustrated by the present book, a 612-page summary describing primarily the advances made in little more than a year. The advances — due mainly to higher-resolution techniques and more sensitive radio telescopes — were reported in Paris at a symposium held at the Cité Universitaire from July 30 to August 6, 1958. This truly international meeting, attended by a large fraction of the world's radio astronomers, was reported on page 620 of SKY AND TELESCOPE for October, 1958.

This book is necessarily a summary, for details of all of a single year's work in radio astronomy would require many volumes, and new papers appear in such numbers that no fully comprehensive report is possible. The Paris symposium volume probably is the first reasonably coherent picture of the entire field. An acquaintance with its contents is a near necessity for anyone who professes interest in this subject.

The history of science demonstrates that progress often occurs in a burst of intense activity, a flinging open of windows and a rush to report what is seen. The techniques of radio astronomy have, indeed, opened a companion atmospheric window to the well-known and long-used optical one.

Radiations from a millimeter or so to 20 or 30 meters in wave length can get through the radio window, but radio waves longer and shorter are completely blocked by the atmosphere. The radio universe is the same as the optical one, but it "looks" very different. While optical observations show us mainly the stars, radio reveals mainly the gases and electron streams around and between the stars. Nevertheless, radio and optical astronomy are not two different branches of science. Only the observing techniques are different; we are viewing the same scene through two different windows.

The astronomical radio spectrum is mostly a continuum of noise, except for the 21-centimeter line arising from cold neutral hydrogen in interstellar space. Like lines in optical spectra, the 21-cm. feature can appear as an emission line overriding a weaker continuum, or as an absorption line cut out of a strong continuous background. The great importance of this unique radio line is that it alone can gauge the extent and speed of motion (by the Doppler shift) of neutral hydrogen in space.

The continuous radio spectrum is of two sorts, thermal and nonthermal. The former is black-body radiation, exactly analogous to its optical counterpart, and likewise obeying Planck's law. This formulates the energy flux at every wave length, from the longest radio waves to the shortest ultraviolet rays, to be expected from a body whose temperature is specified.

Far more intriguing is the nonthermal continuous radiation, strongest at long wave lengths and weakening rapidly toward the shorter. Perhaps the most significant subject discussed at the Paris symposium was the nearly certain identification of nonthermal radiation with the energy lost by relativistic electrons (of high speed and therefore of large effective mass) under acceleration in cosmic magnetic fields.

The symposium volume divides the broad field of radio astronomy into six parts. Studies of thermal radiation from Venus, Mars, Jupiter, Saturn, and the moon, together with radar echoes from the moon, comprise most of the first section. Jupiter is the only planet definitely known to emit nonthermal radiation, this coming in bursts from five or six discrete sources on the Jovian surface, according to R. Gallet. Existence of a residual atmosphere on the moon was reported to be revealed by lunar occultations of radio sources. We are still justified, however, in considering the lunar surface as "vacuum packed."

Part II's more than 200 pages on radio observations of the sun are ably summarized by M. Minnaert in its closing chapter. (An attractive feature of the book is that each major section has both a short introduction and a concluding summary.) Solar radio radiation consists of three parts: that from the ever-present "quiet sun," the "slowly varying component" traced to emitting layers lying directly above a plage, and solar radio bursts. The last generally originate in rapidly ascending disturbances associated with turbulent areas on the sun, which can now be located on the solar disk to a precision of one minute of arc. As yet, the nature of the ascending sources is not clearly understood.

Each year, from June 8th to 21st, the sun occults the Crab nebula, a prominent radio source, thereby providing a means of mapping the structure of the outer corona. The distortion of the source by the corona can be observed as far out as 20 solar radii. The net effect is an apparent progressive enlargement of the source as the sun nears it.

Two closely related sections, III and IV, deal with intra- and intergalactic radio sources. Their observation has contributed greatly to our knowledge of galaxies.

R. Minkowski, long active in the identification of nonthermal radio sources, has derived a new distance of 3,400 par-

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secs for the very strong Cassiopeia A source. This great increase from the old value of 800 parsecs indicates the fluid state of radio astronomy. Another intriguing result is the large radio size of galaxies that emit strongly enough to be observed. For instance, Centaurus A, associated with the galaxy NGC 5128, has radio dimensions of 30,000 by 100,000 parsecs. Our own Milky Way, a giant optical galaxy, is some 30,000 parsecs across.

The radio emission of the Milky Way is a composite of nonthermal and of thermal radiation from H-II (ionized hydrogen) sources. At long wave lengths, the H-II regions appear as absorption features against a "hot" radio background, while at short radio wave lengths they are observed as emission sources against a "cool" background. Thus ionized hydrogen clouds can often be mapped more easily by radio than by photographic methods.

Optical identification of radio sources is still vexing and challenging. Only a small percentage of the many hundreds of discrete sources now catalogued have been identified. Most of the sources are presumably extragalactic, but as a rule they cannot yet be associated with nearby bright galaxies. Only 19 sources have been identified with normal galaxies, all of them late-type spirals, none normal ellipticals. All the so-called radio galaxies, whose emission is several times stronger than that from normal systems, appear to have optical peculiarities.

F. Hoyle and G. C. McVittie discuss the relation of radio astronomy to cosmology, in two papers in part V of the book. Hoyle formulates an observational test for the steady-state theory of the universe. This test, of the angular diameters of radio sources, is on the threshold of ability of present instruments. McVittie, however, abruptly rules out the steady-state theory on existing optical evidence (the negative acceleration of the universe's expansion).

The last of the six sections deals with the origin of solar and cosmic radio emission. G. R. Burbidge, who accepts the explanation we previously mentioned for nonthermal continuous radiation, proposes that the relativistic electrons responsible for this universal radiation are the by-products of collisions of cosmic rays with intergalactic matter. If this is the case, Hoyle comments, radio astronomy becomes a powerful tool in cosmic ray research.

The nonspecialist reader of the Paris symposium volume will certainly be impressed by the outpouring from that modern cornucopia, the radio telescope. He will recognize that radio astronomy is beginning to assume a definite and fascinating pattern. But he will also see that the symposium volume, monumental as it is, will soon become a historical reference work that must have a place in any astronomical reference library.

Both editor and publisher deserve great credit for bringing out this extensive work so promptly, with such excellent editing and printing.

J. ALLEN HYNEK
Smithsonian Astrophysical Observatory

THE SUN

Karl Kiepenheuer. University of Michigan Press, Ann Arbor, Mich., 1959. 160 pages. $5.00.

PERHAPS it is not really the province of a professional solar astronomer to review a popular book on the sun, inasmuch as the test of its success is the effect on the layman. This reviewer can, however, comment on its accuracy and give

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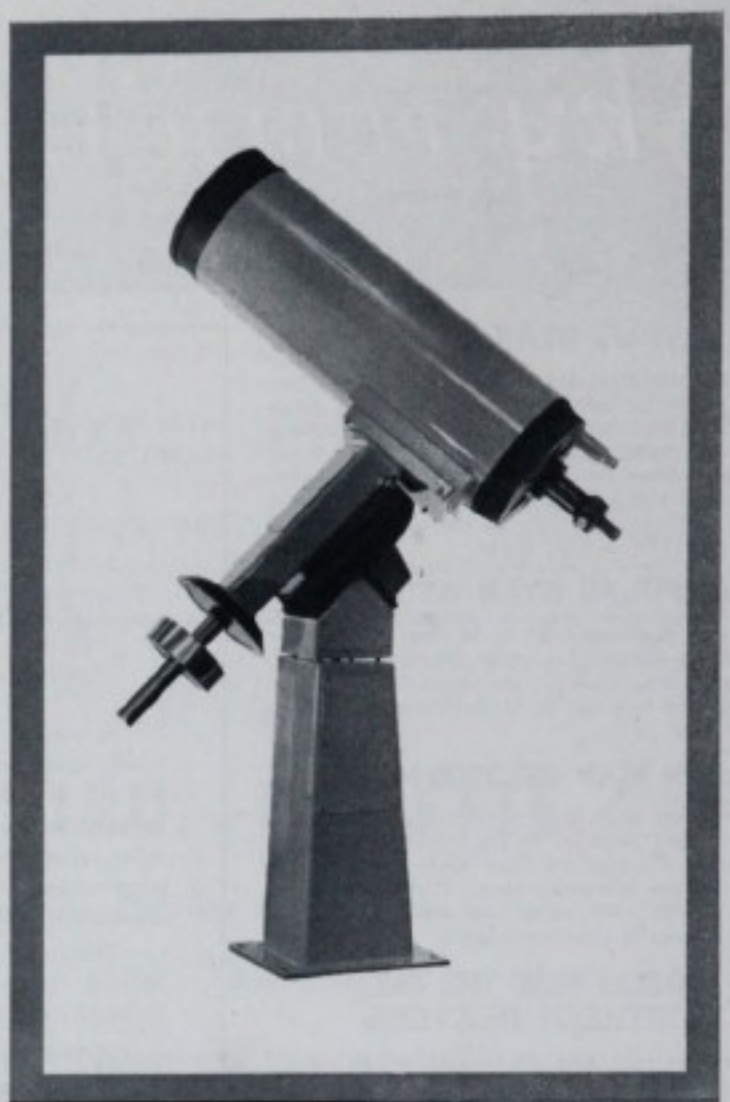

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an opinion on how well it informs the intended reader concerning the status of solar study today.

The present volume is a translation and abridgement of Professor Kiepenheuer's lively and well-written little book, *Die Sonne,* published by Springer-Verlag in 1957. Unfortunately, the translation has considerably watered down the original style, and the abridgement has been carried out simply by omitting entire sentences, to the impairment of the book's logical structure.

Furthermore, physical units have been converted haphazardly. While centigrade temperatures have invariably been changed to Fahrenheit (sometimes without the 1.8 factor), and kilometers per second to miles per hour, centimeters and meters are not always given in feet and inches. The altitude of our observatory in Climax, Colorado, stated correctly as roughly 3,500 meters in the original book, has been incorrectly converted to 10,480 feet in the translation.

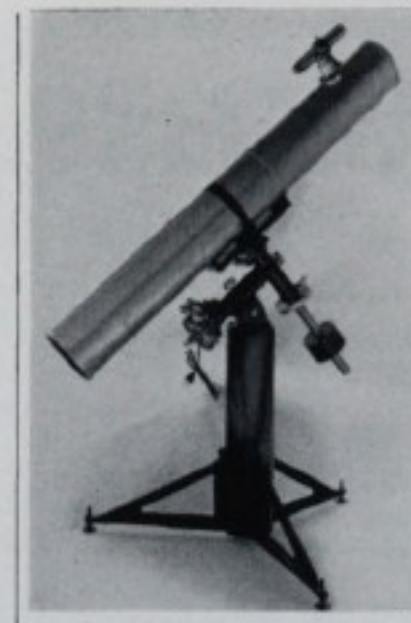
The author himself aptly reviews his own work on the final page. "The smooth course of this journey which led from the glowing interior of the sun to its coldest and outermost planets may have misled the reader into thinking that few problems remain to be solved. Fortunately, this is far from being the case. Simplified accounts like the present book must needs emphasize past achievements at the expense of the discussion of unsolved questions."

Professor Kiepenheuer has drawn a picture of the course of events on the sun, in which the emphasis is on the things we know. In the reviewer's opinion, this stress has sometimes been carried too far. For example, at the end of Chapter 3 the statement that "theoretical considerations and model experiments have enabled astronomers to give a satisfactory interpretation of solar convection phenomena," would not be agreed with by many solar physicists. On the other hand, in 150 pages of text it is admittedly very difficult to go into all the details of the problems.

Because of the delay between the original 1957 book and the appearance of the translation in 1959, certain facets of *The Sun* have become out of date. The advances in solar physics in the past two years — due to the International Geophysical Year, rocket and balloon studies of solar-terrestrial phenomena, and solar radio astronomy — have made many changes. It is rarely possible to keep up with the rapid progress of science, and the extra delay due to translation is therefore doubly unfortunate.

Certain errors merit pointing out. On page 44 a high-resolution vacuum spectrogram in hydrogen-alpha light is presented, with the remark that this exhibits granular structure, whereas it actually shows chromospheric fine structure.

In Chapter 7 the author lumps all prominences together in the filamentlike class, and states that they all have life-



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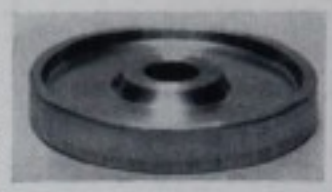

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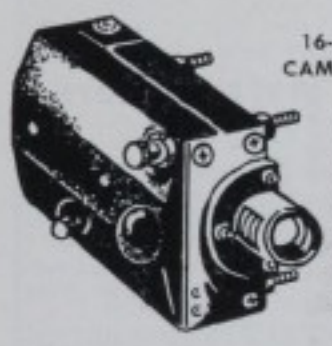

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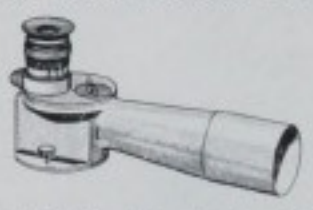

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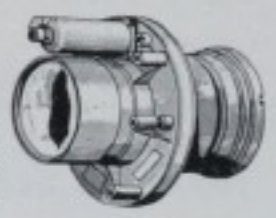

Focal length 36". Completely mounted with iris and shutter. Weight approx. 25 lbs. Excellent condition.

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Waterproof carrying case extra. Shipping wt., 3 lbs. Price **$3.00**

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Produces visible image from infrared image in complete darkness. For seeing in dark with infrared light source. Nothing to wear out. Operates on two flashlight batteries. Has high-voltage power supply and image tube (1P25) and elaborate optical system. Weighs only 6¼ pounds and is only 11" long, 8" high, 5-12" wide. Manufactured by R. C. A. Objective f/0.9 Schmidt system, 2.4" focal length, 3¼" aperture. Excellent condition, with waterproof carrying case. Price **$35.00**

INFRARED FILTERS

5⅜" diam. x ⅛" thick. Price **$2.95**

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times of the order of months. As observers of prominences know, there are numerous different types, which lead to various classification schemes. Many have very short lifetimes; individual loop prominences, for example, last only a few hours.

Professor Kiepenheuer discusses the condensation of prominences in regions of low coronal intensity, which indicates that the corona has condensed out into the prominence. This statement is perfectly correct, so far as I know, if "filament" (or "quiescent prominence") is substituted for "prominence." Certainly, loop prominences and coronal rain are only observed at points of the very highest coronal intensity (hence highest density).

In general, this well-illustrated book provides a concise and easy-to-read introduction to solar physics, which will be appreciated by many novices to the field. The more informed amateur, however, will do better to turn to Kiepenheuer's fine article in G. P. Kuiper's *The Sun*.

HAROLD ZIRIN
High Altitude Observatory

PLANETARIA AND THEIR USE FOR EDUCATION

Miriam Jagger, editor. Cranbrook Institute of Science, Bloomfield Hills, Mich., 1959. 205 pages. $3.50, paper bound.

THIS is a compilation of some 40 papers presented at a symposium in September, 1958, at the Cranbrook Institute of Science, to which representatives from 120 planetariums in the United States had been invited. Conducted under a grant from the National Science Foundation, the meeting gave the 101 registrants opportunity to exchange ideas.

As the editor points out in the preface, "in the field of audio-visual aids there is perhaps no more fascinating or potent an educational device than the planetarium. . . . Speakers at the symposium cited one instance after another in which planetaria have not only drawn capacity audiences to their own programs, but have stimulated new public interest in the programs of affiliated museums and observatories."

In discussing the educational task of a planetarium, M. H. Degani, of the State University Maritime College in Ft. Schuyler, New York, remarks that most lectures present an incomplete picture of the universe — "just small pebbles in a mosaic." The planetarium demonstration should include the components that make up our world and the way these are put together, a scale of distances, the idea of time, and a brief history of the universe.

Although the symposium was suggested by and planned for planetarium officials, many of the papers are of general interest to educators in this space age. The book should also appeal to the layman.

M. T. BRACKBILL
Eastern Mennonite College
Harrisonburg, Va.

NEW BOOKS RECEIVED

LAROUSSE ENCYCLOPEDIA OF ASTRONOMY, *Lucien Rudaux* and *G. de Vaucouleurs*, 1959, *Putnam's*. 506 pages. $15.00.

This English version of a comprehensive French survey of astronomy at the popular level is a translation by M. Guest and the late J. B. Sidgwick, with revisions by Z. Kopal. It has over 800 illustrations, many full-page size (8 by 11⅛ inches) and in color. Its first section is headed "The Splendour of the Heavens," this volume being a modern counterpart to the famous English work of that title published a third of a century ago.

STANDARD HANDBOOK FOR TELESCOPE MAKING, *N. E. Howard*, 1959, *Crowell*. 326 pages. $5.95.

Full instructions are given for the construction of an amateur's Newtonian reflector, from grinding the mirror to adjustment of the mounting.

PRINCIPLES OF OPTICS, *Max Born* and *Emil Wolf*, 1959, *Pergamon*. 803 pages. $17.50.

Intended for the advanced student, this comprehensive treatise on geometrical and physical optics is largely mathematical in character. It is a modernized and considerably enlarged English revision of a standard work originally published in German in 1933, Max Born's *Optik*.

APPLIED SOLAR ENERGY RESEARCH, *Jean Smith Jensen*, editor, 1959, *Association for Applied Solar Energy*, 3424 N. Central Ave., Phoenix, Ariz. 275 pages. $7.50.

The current state of research into harnessing the sun's energy is summarized in this annotated bibliography of 2,916 books and articles. It is complete to the end of 1958, and includes many pre-1954 papers not listed in the first edition of this work, published at Stanford in 1955.

ASTROPHYSIQUE GENERALE, *J. C. Pecker* and *E. Schatzman*, 1959, *Masson et Cie.*, 120 Blvd. St.-Germain, Paris 6, France. 756 pages. 13,000 fr cloth, 12,000 fr paper bound.

Every branch of astrophysics, observational as well as theoretical, is covered in this college textbook by two leading Paris astronomers, intended for students with a background of physics and mathematics. There are 396 illustrations, and each chapter has a brief bibliography.

RADIO STUDIES OF THE UNIVERSE, *R. D. Davies* and *H. P. Palmer*, 1959, *Van Nostrand*. 200 pages. $5.00.

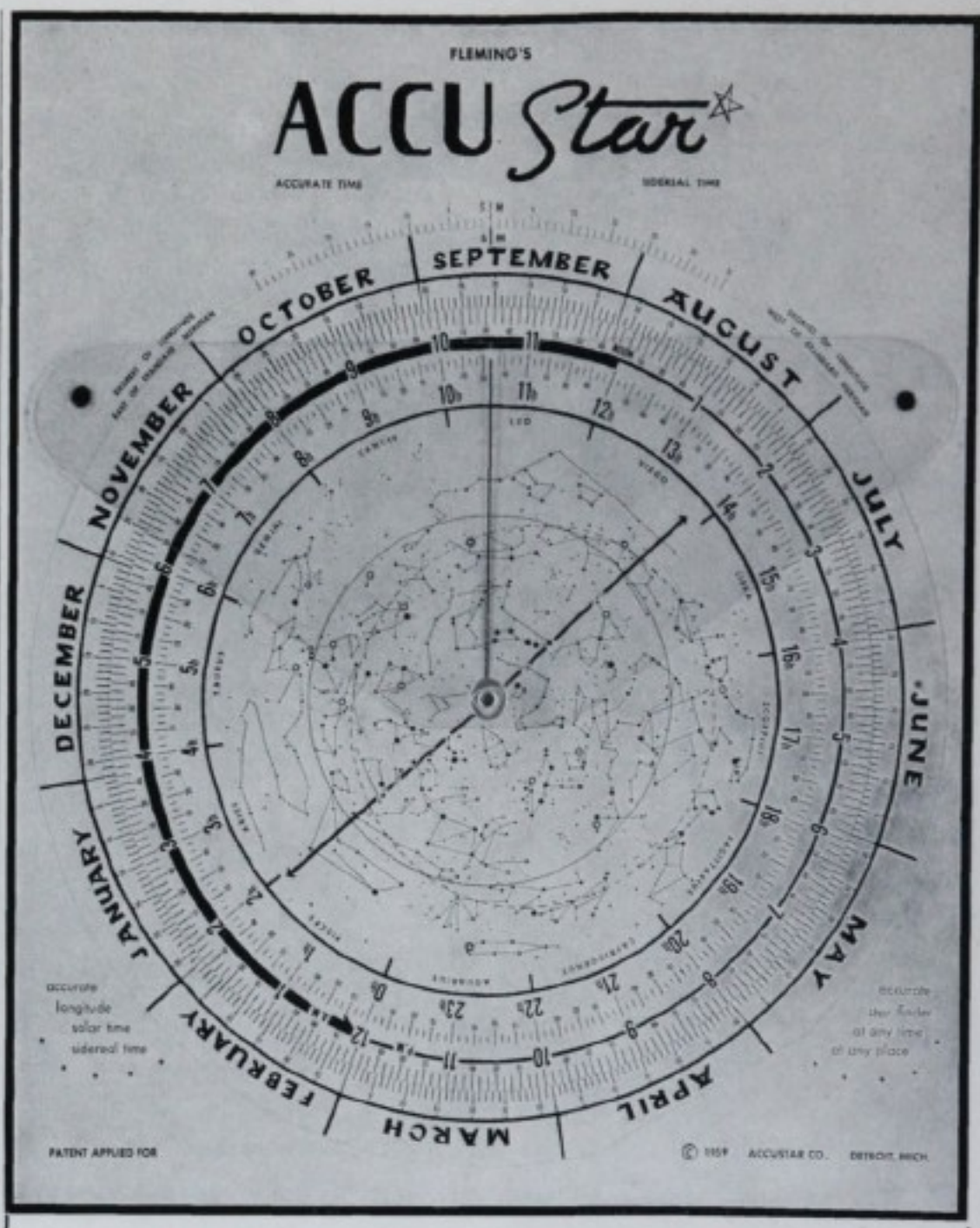
Radio telescopes and the deep effect their discoveries have had on astronomy in general are described for well-informed laymen in this book by two British radio astronomers, both of whom work at Jodrell Bank.

THE TRANSITS OF VENUS, *Harry Woolf*, 1959, *Princeton University Press*. 258 pages. $6.00.

The historical importance of the 1761 and 1769 transits of Venus to astronomy and to the scientific community at large is here interpreted. The source material consists of archives, memoirs, and much previously unpublished correspondence.

PLANET EARTH, 1958, *National Academy of Sciences*, Publications Office, 2101 Constitution Ave. N.W., Washington 25, D. C. 43 pages. 50 cents, paper bound.

Designed as a teaching aid on the high school level, *Planet Earth* is a booklet describing the earth, solar-terrestrial relationships, and space. It is part of an integrated set of six posters and project leader's kit.



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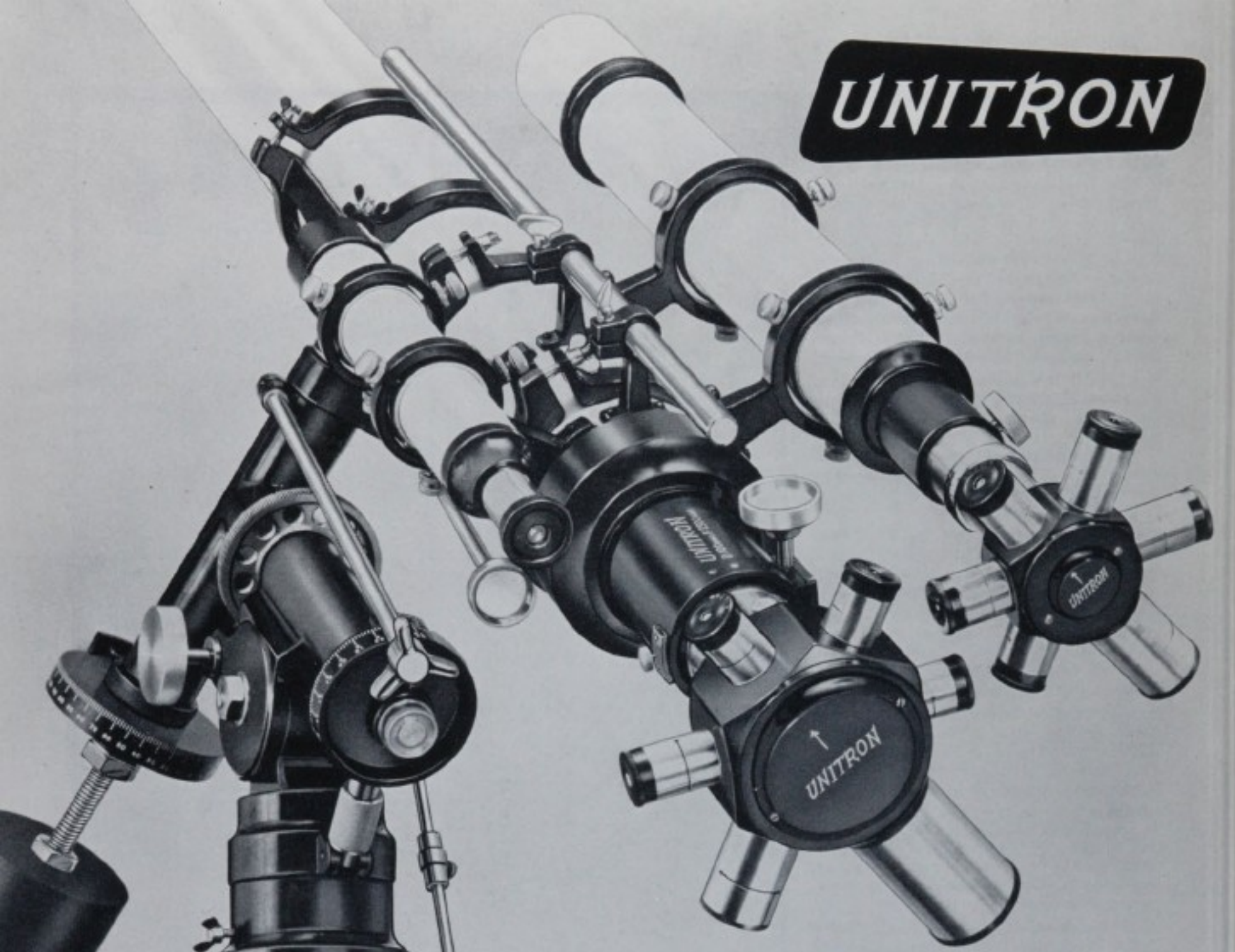

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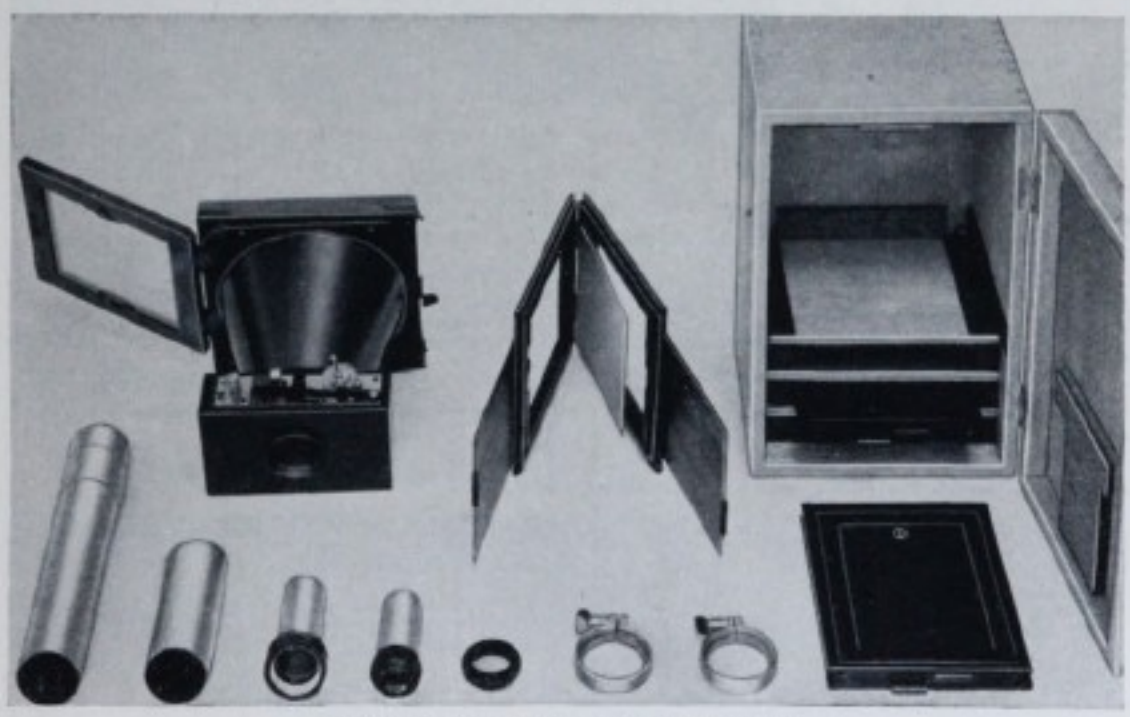

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A lightweight camera designed especially for photography using the objective lens (or mirror) of the telescope as the principal optical element. The camera may be positioned so that a picture is taken of the image at the primary focus. Alternately an eyepiece may be inserted in the camera tube and camera placed so as to project a magnified image on the plane of the film. It is supplied complete with Thornton-Pickard type shutter, speeds 1/10 to 1/90 second, bulb, and time, 3 double plate (or cut film) holders 3¼" by 4¼", ground-glass focusing back, extension tubes, 30-mm. f.l. photo-ocular, eyepiece holder, clamps, cabinet and instructions.

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A tolerance of 5% in focal length is customary. A deposit of ⅓ is required with orders for 8" to 12" mirrors.

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3"	**$3.00**	6"	**$6.00**
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Kellner 9-mm. f.l. (⅜")	**7.90**
Kellner 7-mm. f.l. (9/32")	**8.50**
Kellner 12.7-mm. f.l. (½")	**9.50**
Orthoscopic 6-mm. f.l. (¼")	**12.50**
Orthoscopic 4-mm. f.l. (5/32")	**14.50**

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The Criterion Revolving Turret holds three eyepieces so that, as desired, the power of the telescope can be changed by merely turning the turret to a different ocular. Click stop insures positive and accurate positioning of each eyepiece. Turret holds eyepieces of standard 1¼" outside diameter. Fits into the holder of any refractor or reflector telescope that uses 1¼" eyepieces. Requires no alteration or adjustment and can be attached as easily as putting eyepiece into scope. Made of brass and aluminum with polished chrome-plated barrels.

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Diagonal Rod — Cat. #SU-9R..... **$1.00**

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- Sunshade extension with dewcap on all sizes.

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S-210	60 mm. (2.4")	910 mm. (35.8")	**$19.95**
S-220	3"	1250 mm. (49.2")	**52.00**
S-230	4"	1600 mm. (62.9")	**95.00**

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Cat. #	Minor-Axis Size	For Tubes	Price
S-51	1.25"	6½" to 7½"	**$10.00**
S-52	1.30"	6½" to 7½"	**10.00**
S-53	1.50"	8½" to 9½"	**10.00**
S-54	1.75"	9½" to 10½"	**12.50**
S-55	2.00"	11" to 11½"	**14.95**
S-56	2.50"	Specify tube I.D.	**19.95**

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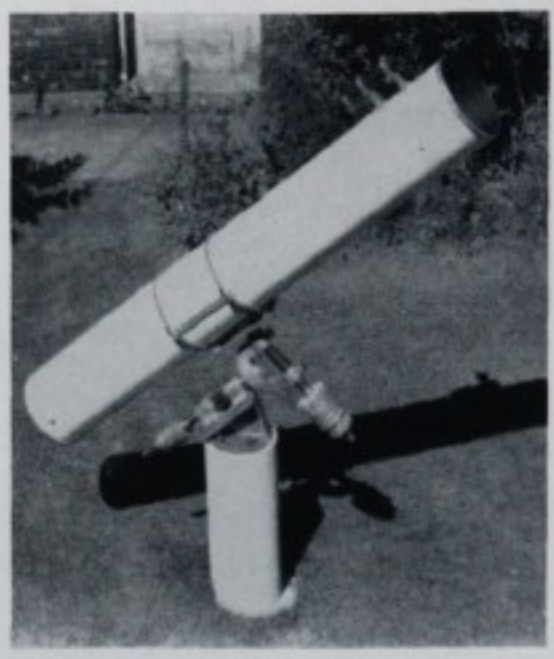
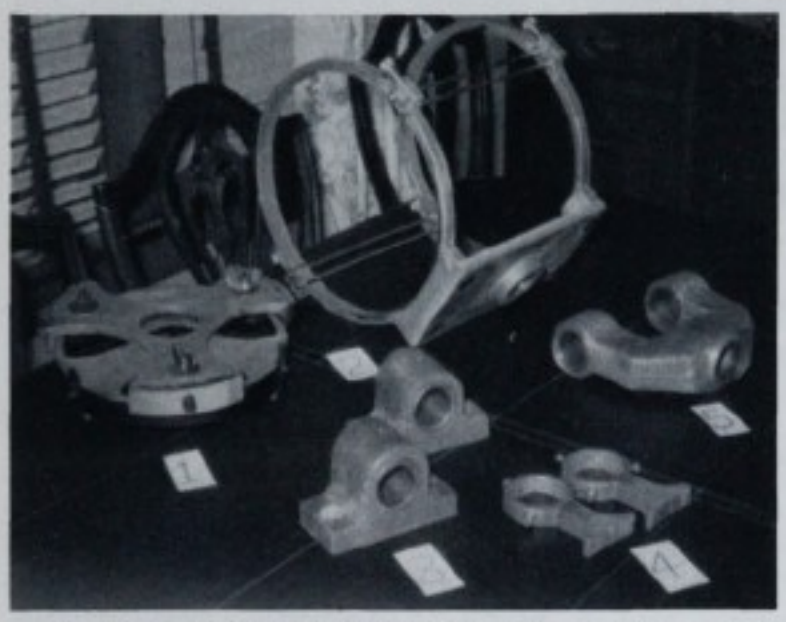
Casting the Parts of an Aluminum Mounting

THE ARTICLE on metal castings by William Cheney in this department last June and July has encouraged me to relate how my casting problems for a 10-inch f/8 Newtonian reflector were solved.

First, patterns were made from white pine, a soft wood easy to work with and shape. Molds were made with fine foundry sand, and the cope-and-drag casting method was used. Details of this procedure were given here in the July and August, 1952, issues, and may also be found in *Amateur Telescope Making — Book II,* pages 339-364. This was my first attempt at sand-casting. Although a few castings were spoiled, I was able to produce better ones with a minimum of effort.





This 10-inch reflector with equatorial mounting was made by Joseph L. Acsbock of parts he molded and cast himself. Some of the units are identified at the left: 1, mirror cell; 2, cradle and slip rings for tube; 3, bearing supports for polar axle; 4, finder mounting brackets; 5, bearing support for declination axle.

Aluminum melts at 1,220° Fahrenheit, a temperature not difficult to achieve under limited workshop conditions. Scrap-aluminum auto pistons were placed in a heavy cast-iron melting pot, heated over a small charcoal stove. Although the aluminum liquefied easily, I do not recommend this method for melting bronze.

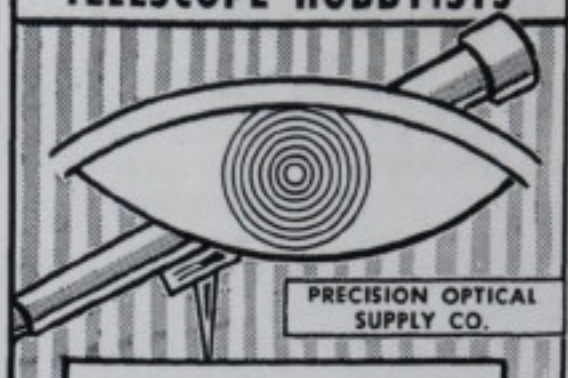
A local machinist faced and trued all the castings, and did the machine work for the rest of the mounting parts. The axles rotate in babbitted bearings. Its motion is smooth enough for a clock drive and setting circles to be added to the assembly later.

Two years of spare time went into building the telescope, including grinding, polishing, and figuring the mirror. The results were worth the effort.

JOSEPH L. ACSBOCK
3804 Drummond St.
E. Chicago, Ind.

Aluminum auto pistons were melted and poured into molds of fine sand to make parts for the 10-inch telescope. At the left, a section of a rotating-tube ring is being cast, and at the right the cooled casting is being inspected. For safety's sake, goggles and heavy gauntlets are worn.

TELESCOPE HOBBYISTS



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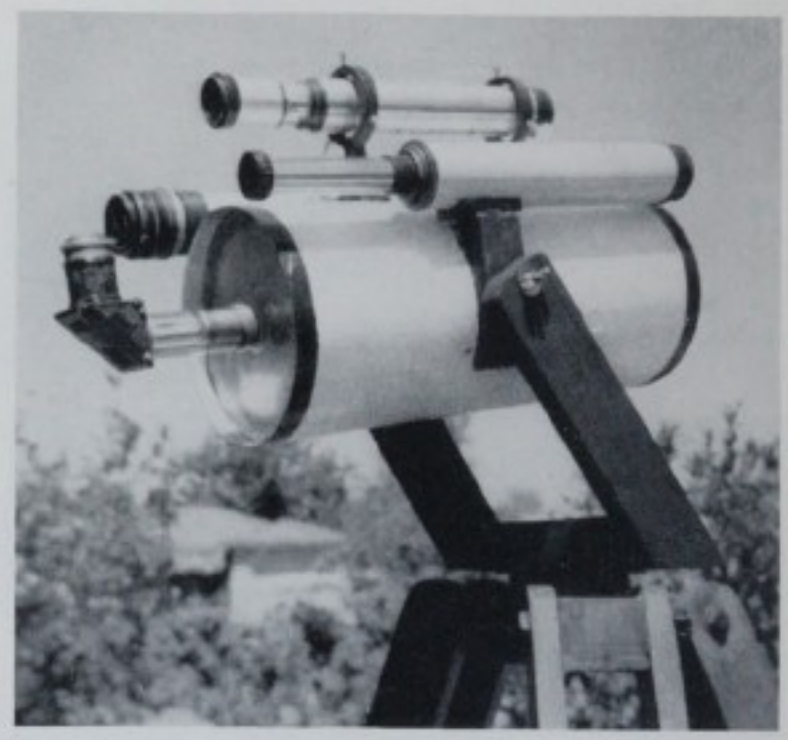
THE BATTERY of instruments pictured here consists of my recently completed 6-inch Maksutov telescope, a 3-inch rich-field with a giant Erfle eyepiece, a 20-power terrestrial telescope, and a 10-power finder having a 1¾-inch objective and Erfle ocular. With this all-purpose assembly I can do almost anything from bird watching to counting craterlets in Plato.

The rich-field instrument covers a 7½-degree field and gives a truly spectacular view of the Milky Way. It also enables me quickly to locate nebulae, star clusters, and other faint objects, for observation in the 6-inch catadioptric telescope. The latter performs beautifully and is a joy to use.

Let me offer a word of encouragement to those who contemplate making a Maksutov telescope. All of my lens surfaces were completed entirely with the use of accurate glass templates. These were made from glass cut to an approximate curve and ground together with No. 400 carborundum until the templates fitted exactly with each other. Then, to determine contact between lens and template, I used strips of Saran wrap, which has a thickness of less than 0.001". I recommend this method only for those who do not have an accurate and dependable spherometer.



The main instrument of James A. Wells' assembly is a 6-inch Maksutov, carried on a fork-type altazimuth mounting. Alongside the Maksutov and nearest the camera in this picture is a 30-power terrestrial telescope. At the top is the 10-power finder, while a 3-inch rich-field instrument is on the far side of the main tube, but only its giant Erfle eyepiece can be easily seen.

JAMES A. WELLS
2428 E. Verde Lane
Phoenix, Ariz.

THE TWYMAN EFFECT IN DIAGONALS

REFLECTING TELESCOPES after assembly sometimes give images inferior in quality to those expected from the finished-surface tolerances of the primary mirror and diagonal. Often a lack of crispness is blamed on the eyepiece, as this is the one component that the average amateur has no way of checking independently of the rest of his optical system. However, unknown to the builder, the figure on the diagonal may have changed seriously and be causing the trouble.

Both the front and back of the diagonal are polished during figuring so that the fringe pattern can be seen through the glass. After the desired figure has been obtained, the back of the glass is often ground with a fine or medium abrasive, to insure that the reflecting coating is

put on the right side. This grinding releases stresses placed in the glass during polishing, and springs the figure out of shape.

The resulting deformation of the surface is known as the Twyman effect, after the English optical worker who first called attention to it some years ago. The effect is similar to the deformation of a Cassegrainian primary mirror when it is perforated *after* figuring. One amateur reported that just enlarging the hole through the center of his finished Maksutov primary caused the figure to change by half a wave length of light.

The poorer the annealing and the more numerous the interior imperfections of the glass from which a diagonal is made, the greater the Twyman effect will be. Pyrex and inexpensive plate glass are the worst offenders, while well-annealed optical glass shows the smallest change. In one case, three 3-inch quartz flats were to be made with front surfaces accurate to 1/20 wave of sodium light. Both sides were polished to about ½ wave, and the faces finished to the required perfection. Then the customer requested that the backs be ground, but when this was done, all three elements became concave by ½ to ¾ wave, and they had to be figured all over again.

A very common defect in elliptical diagonals that are shaped after figuring is a general concavity of the surface, as well as a slightly turned-up edge on the thin part of the face.

One way to insure a good diagonal is to check the figure after the back is ground. It is better still to grind the back *before* polishing the front. In testing diagonals, usually the surface is placed face down on a master flat. If a master is not available, then three similar pieces of glass are tested together, and the figure on each is determined algebraically (see *Making Your Own Telescope*, by Allyn J. Thompson, page 103).

One difficulty is viewing the fringes through the ground back. Wetting the surface does not help, as evaporation causes temperature changes that will alter the figure. Many professional shops have found that clear plastic, sprayed heavily on the back of the diagonal and allowed to harden without being touched, dries in a transparent surface through which the fringes can be checked.

The idea has occurred to some amateurs constructing correcting lenses for Maksutov telescopes to make the front aperture oversize, to allow for a possible turned edge during polishing. Later the extra diameter would be ground off. This is a dangerous procedure, as it may change the figures of the lens surfaces.

When working any optical surface to a close tolerance, the best way to avoid the Twyman effect is to do as much of the shaping as possible by grinding before polishing begins, and to do any final shaping before figuring.

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The cradle is another piece of tubing, lined with felt. It was first cut in half with a torch. Then four metal lugs were welded along the edges of the cut. The lugs were drilled and tapped for bolts and wing nuts, for tightening the cradle around the telescope tube.

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The counterweight is an old belt wheel bored to fit the shaft. A clutch was added at the end of the declination axle housing to prevent movement in this co-ordinate while tracking objects. Later improvements will include a clock drive and slow motions.

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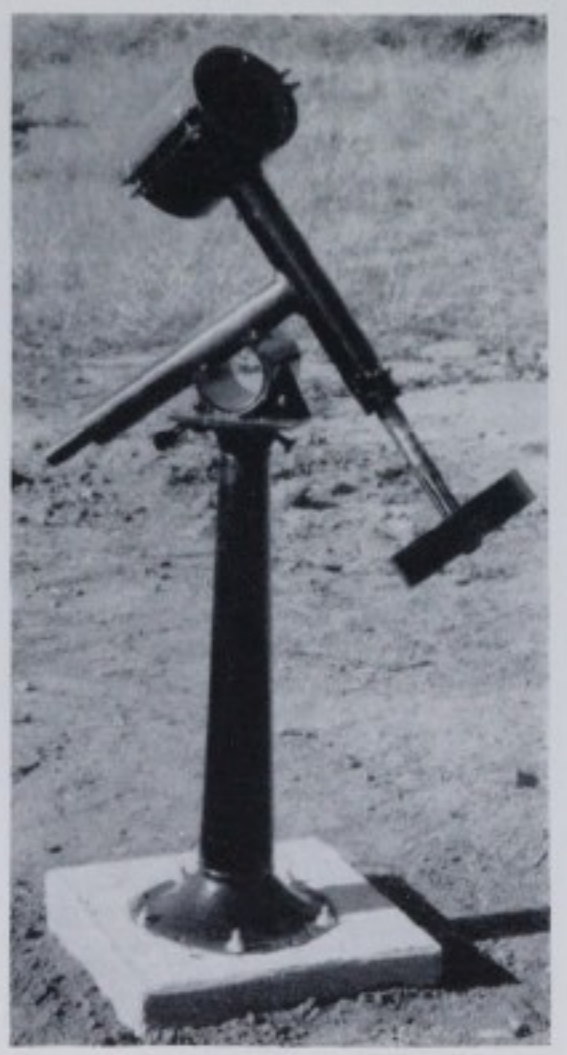
ROBERT V. JAMES
5430 Jigger Dr.
Sopuel, Calif.



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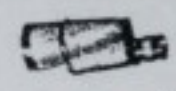

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54 mm. (2⅛")	390 mm. (15.4")	9.75	83 mm. (3¼")	876 mm. (34½")	28.00
54 mm. (2⅛")	508 mm. (20")	12.50	83 mm. (3¼")	1016 mm. (40")	30.00
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54 mm. (2⅛")	762 mm. (30")	12.50	108 mm. (4¼")	914 mm. (36")	60.00
54 mm. (2⅛")	1016 mm. (40")	12.50	110 mm. (4⅜")*	1069 mm. (42-1/16")	60.00
54 mm. (2⅛")	1270 mm. (50")	12.50	110 mm. (4⅜")	1069 mm. (42-1/16")	67.00
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MINIMA OF ALGOL

The Algol minimum of October 20, 1959, was observed photoelectrically by K. C. Chou, of Flower and Cook Observatory, University of Pennsylvania. The average of the times of minimum that he determined in three colors independently is Julian day 2,436,861.7519 (heliocentric). This is only one minute earlier than the corresponding prediction in SKY AND TELESCOPE.

January 2, 19:10; 5, 16:00; 8, 12:49; 11, 9:38; 14, 6:28; 17, 3:17; 20, 0:06; 22, 20:56; 25, 17:45; 28, 14:34; 31, 11:23.

February 3, 8:12; 6, 5:02; 9, 1:51.

These minima predictions for Algol are based on the formula in the 1953 *International Supplement of* the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.

JANUARY METEORS

The Quadrantid meteor shower comes to a sharp peak early on the night of January 3-4. Conditions should be fairly favorable, as the moon is a waxing crescent at this time. Up to 40 meteors per hour may be seen, radiating from northern Bootes. W. H. G.

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Classified advertising costs 30 cents a word, including address; minimum charge, $4.00 per ad. Only one *for sale* ad per issue for each advertiser. *Remittance must accompany order.* Insertion is guaranteed only on copy received by the 20th of the second month before publication; otherwise, insertion will be made in next issue. We cannot acknowledge classified ad orders. Sky Publishing Corporation assumes no responsibility for statements made in classified ads, nor for the quality of merchandise advertised. Write Ad Dept., *Sky and Telescope*, Harvard Observatory, Cambridge 38, Mass.

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FOR SALE: Various eyepieces, etc. Write W. Smysor, Jr., 1709 Goshen Pike, Milford, Ohio.

CELESTIAL CALENDAR

Universal time (UT) is used unless otherwise noted.

OCCULTATIONS IN JANUARY

ALDEBARAN will be occulted by the moon on the morning of January 10th, but only for observers in the north central and northwestern states and western Canada. Nevertheless, observers elsewhere who watch the gibbous moon and the 1st-magnitude star that night will see them close together in the sky, and the moon's motion past the star will be very noticeable. This is the first of seven occultations of Aldebaran in 1960 for observers in North America.

Details of this occultation and of others were published last month in the Occultation Supplement, which should be consulted for data for predictions at places other than the standard stations.

At station **F**, in Illinois, the emersion of Aldebaran will take place at 3:45 a.m. Central standard time, at a position angle of 139°, measured on the moon's limb eastward from the north point.

At Denver, Colorado, station **H**, Aldebaran will disappear behind the moon's dark limb at 2:57 a.m. MST, 165°, and reappear 15 minutes later at 194°. Places somewhat south of that station will see a grazing occultation. While the star is near the moon, their color contrast should be striking.

The most favorable occultation predictions given are for stations **J** and **M**, Edmonton and Vancouver, in western Canada, with the occultation beginning near 1:15 a.m. PST and lasting about an hour.

MINOR PLANET PREDICTIONS

Bellona, 28, 10.8. December 28, 7:23.1 +11-47. January 7, 7:14.3 +12-32; 17, 7:05.2 +13-30; 27, 6:57.1 +14-33. February 6, 6:51.1 +15-34. Opposition on January 8.

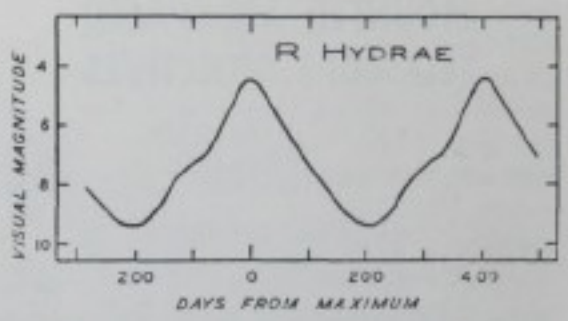
Hygiea, 10, 10.7. January 17, 9:58.1 +9-11; 27, 9:52.1 +9-29. February 6, 9:44.7 +9-55; 16, 9:36.7 +10-27; 26, 9:28.8 +11-00. March 7, 9:21.7 +11-30. Opposition on February 12.

After the asteroid's name are its number and the photographic magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

MOON PHASES AND DISTANCE

First quarter	January	5, 18:53
Full moon	January	13, 23:51
Last quarter	January	21, 15:01
New moon	January	28, 6:16
First quarter	February	4, 14:27

January	Distance	Diameter
Apogee 10, 13h	252,300 mi.	29′ 26″
Perigee 26, 10h	224,800 mi.	33′ 02″
February		
Apogee 7, 6h	251,800 mi.	29′ 30″



This mean light curve for R Hydrae was compiled by the late Leon Campbell from brightness estimates made by members of the American Association of Variable Star Observers. Adapted from "Studies of Long Period Variables," published by the AAVSO.

R HYDRAE

SOME clear January morning, during the pre-dawn hours, look low in the southeast, below Spica and to the east of Corvus, to find Gamma Hydrae, in the tail of the Sea Serpent. This 3.3-magnitude star will be seen — preferably in binoculars — to be flanked by two others, Psi Hydrae (magnitude 5.1) to the right, and red R Hydrae to the left.

This last, a famous variable star, will be at maximum light about the end of January, and probably about a match for Psi. Its brightness changes were first noted by the Italian astronomer Montanari just about three hundred years ago.

When fairly regular observations began, early in the 17th century, the period of R Hydrae was about 500 days, but there has been a steady shortening until the value listed in the latest variable star catalogue is only 386.2 days. This remarkable alteration is practically unique among variables, R Aquilae alone showing a similar but smaller effect.

In a telescope of fair size, look for the 12½-magnitude companion 22″ south of R, a difficult object when the variable is at maximum.

VARIABLE STAR MAXIMA

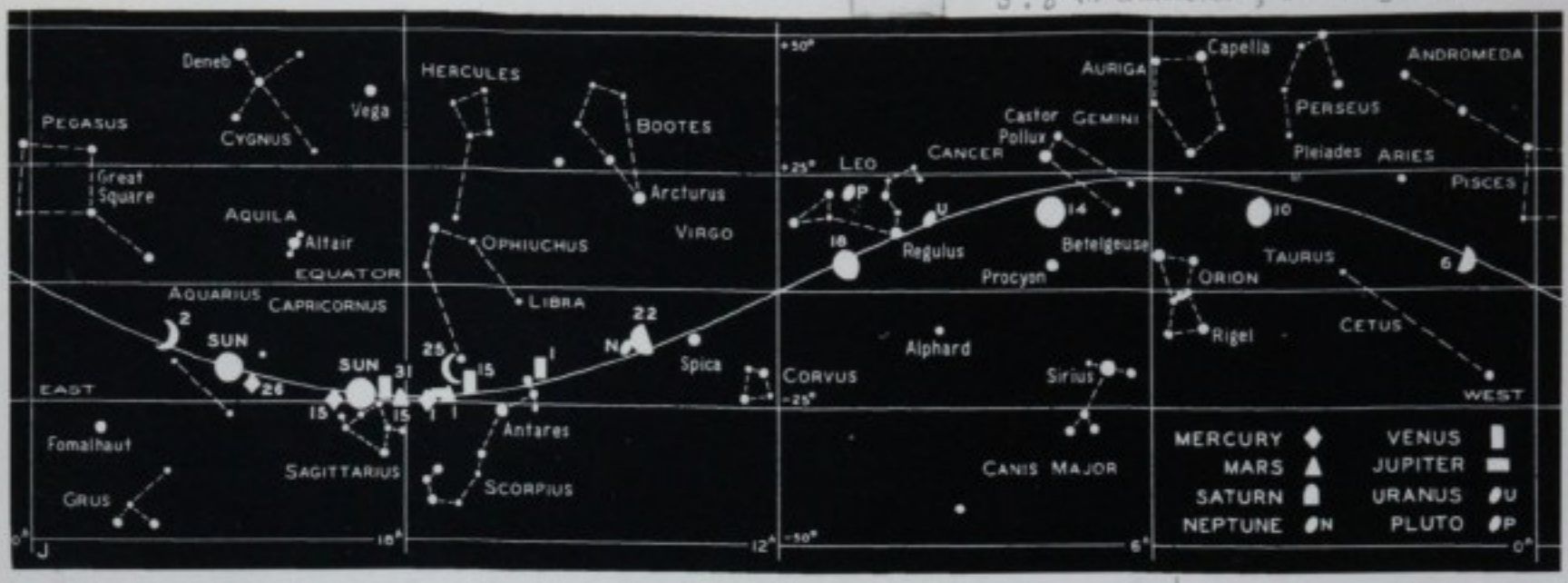
January 2, R Trianguli, 023133, 6.2; 5, S Sculptoris, 001032, 6.8; 8, R Virginis, 123307, 6.9; 12, T Ursae Majoris, 123160, 7.7; 14, R Canis Minoris, 070310, 8.0; 14, V Cancri, 081617, 7.9; 25, S Ursae Majoris, 123961, 7.8; 26, V Cassiopeiae, 230759, 7.9; 29, R Aquarii, 233815, 6.5; 30, R Hydrae, 132422, 4.5; 31, RV Sagittarii, 182133, 7.8.

February 5, U Ceti, 022813, 7.5; 7, R Reticuli, 043263, 7.6; 7, RT Cygni, 194048, 7.3; 8, S Gruis, 221948, 7.7; 9, R Andromedae, 001838, 7.0.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

Appearance of Uranus at 225x, 6" f/7.5 Reflector:
on the night of Dec. 26-27, 1960

(Tiny, greenish disk)
3".8 in diameter, 6th magnitude



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other dates shown. All positions are for 0h Universal time on the respective dates.

Mercury is too near the sun in the sky this month to be generally seen, superior conjunction occurring on January 26th.

Venus rises nearly three hours before the sun in midmonth, being in southern Ophiuchus. Brilliant at magnitude −3.5, it can be easily found in the southeastern sky during morning twilight. The disk is 14".7 in diameter and 76.1-per-cent illuminated. Venus will be in conjunction with Jupiter on the morning of January 21st, being about a degree north at 11h Universal time. The moon will be near both of these planets on the morning of the 25th.

Mars is a 2nd-magnitude object in Sagittarius, rising only 1½ hours before the sun and not easy to observe in the morning twilight.

Jupiter is a bright object, low in the southeast before dawn; on January 15th its magnitude is −1.4 and it is in southern Ophiuchus, rising about two hours before sunup. A telescope will show its slightly flattened disk, 30".0 in polar diameter, 32".2 in equatorial. On the morning of January 21st this giant planet is in conjunction with Venus. On the morning of the 25th the moon will pass about 5° north of Jupiter.

Saturn is too close to the sun to be seen during the first part of the month, but by the end of January it may be possible to find it with binoculars low in the southeast, where it will rise about 1½ hours before the sun. At this time the ringed planet is of magnitude +0.8. Mars will pass 1°.2 south of Saturn on the 31st, with conjunction occurring at 11h UT.

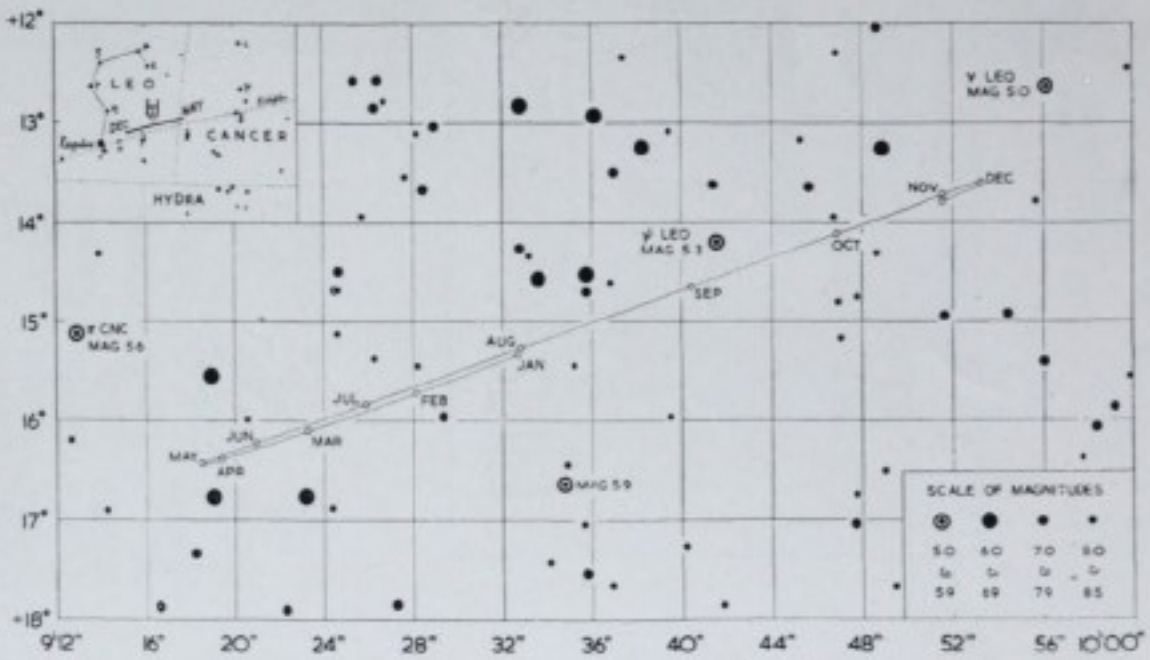
Uranus is in Leo and well placed for viewing, as it rises about two hours after sunset. Being of the 6th magnitude, it is easily visible in field glasses. On the 15th the planet will be located at right ascension 9h 30m.3, declination +15° 33′ (1950 co-ordinates). The daily motion is −0m.15 in right ascension and +0′.7 in declination.

Neptune is an 8th-magnitude planet in western Libra, at 14h 28m.0, −12° 46′ (1950) on the 15th. It may be seen in the southeastern sky in the early morning, and it transits just before sunrise.

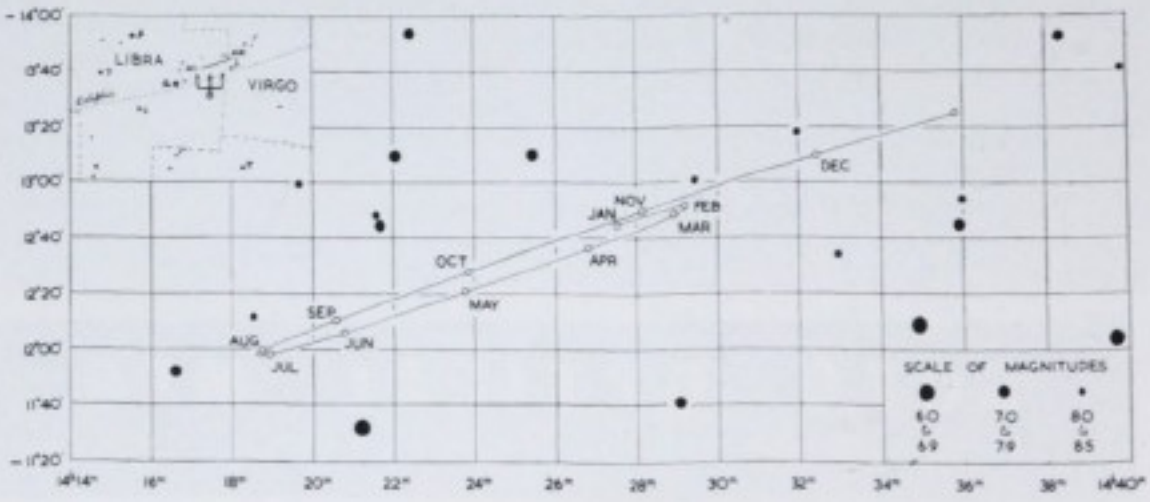
Pluto is a 15th-magnitude object in Leo, and may be seen in large amateur telescopes. On the 15th it is located at 10h 49m.6, +21° 04′ (1950), more than 10° from the ecliptic. There are no bright stars nearby. Opposition will occur on February 24th. W. H. G.

UNIVERSAL TIME (UT)

TIMES used in Celestial Calendar are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown. For example, 6:15 UT on the 15th of the month corresponds to 1:15 a.m. EST on the 15th, and to 10:15 p.m. PST on the 14th.



The path of Uranus among the stars of Cancer and Leo is shown above; that for Neptune among the stars in Virgo and Libra, below. In each case the field is inverted, with south at the top. (The insets have north at the top.) The scales of the two charts are not the same. From the 1960 "Handbook" of the British Astronomical Association, courtesy J. G. Porter, editor.



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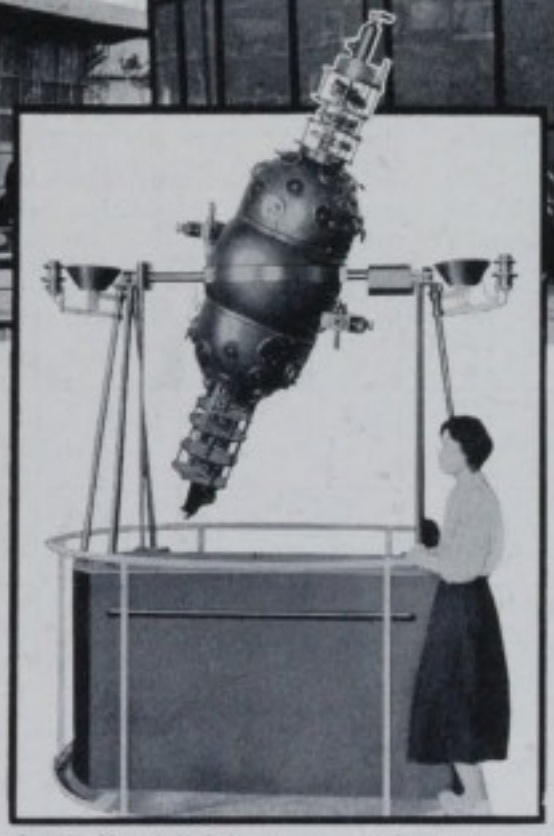

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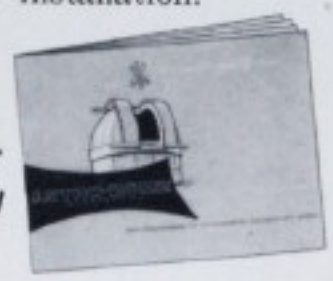

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See our important announcement on page 179.

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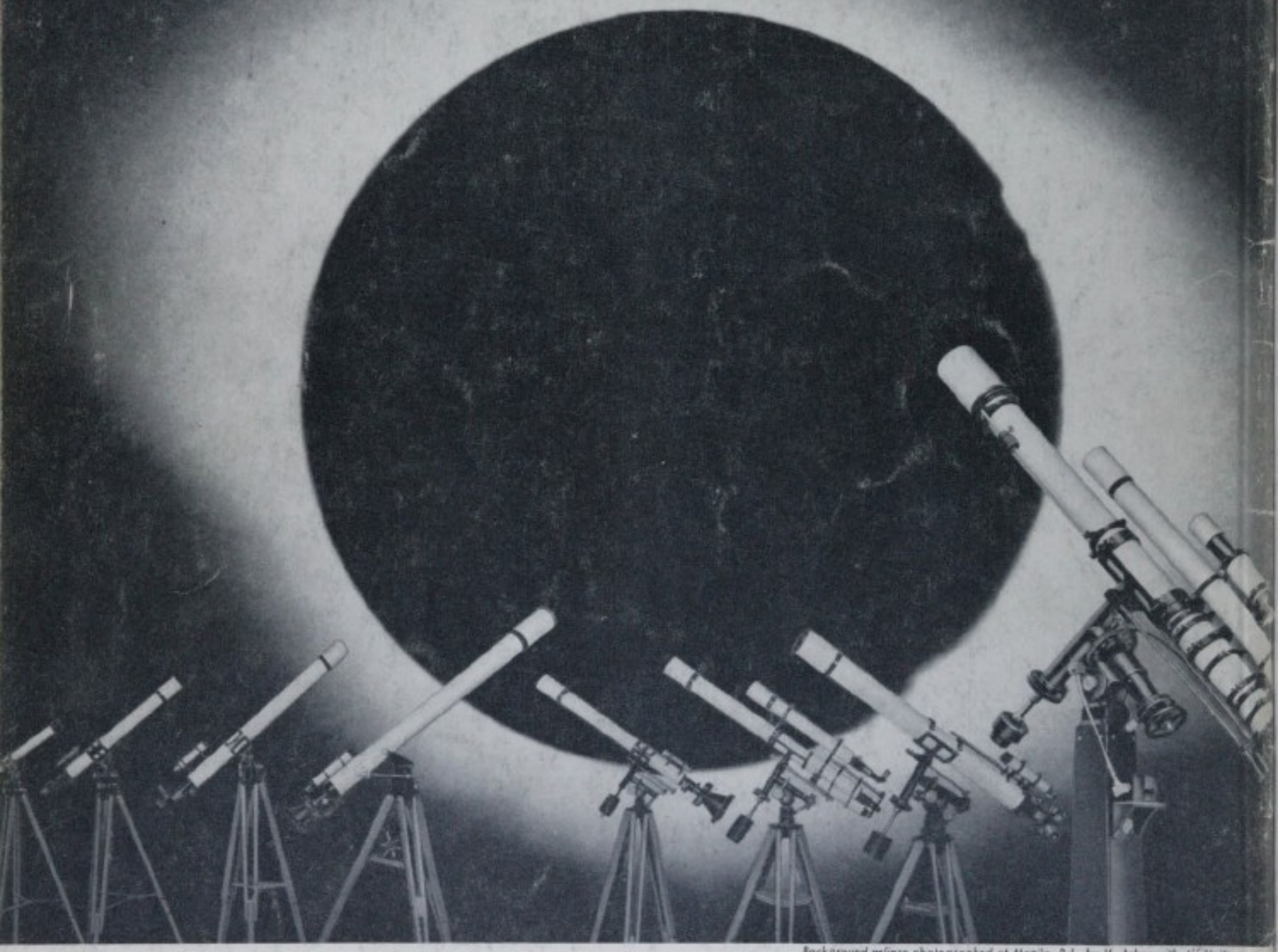

Background eclipse photographed at Manila, P.I., by H. Arber with 4" Unitron.

2" SATELLITE — 6x, diagonal eyepiece, altazimuth mount with circles, stand **$75**
1.6" ALTAZIMUTH — with eyepieces for 78x, 56x, 39x **$75**
2.4" ALTAZIMUTH — with eyepieces for 100x, 72x, 50x, 35x **$125**
2.4" EQUATORIAL — with eyepieces for 129x, 100x, 72x, 50x, 35x **$225**
3" ALTAZIMUTH — with eyepieces for 171x, 131x, 96x, 67x, 48x **$265**
3" EQUATORIAL — with eyepieces for 200x, 131x, 96x, 67x, 48x **$435**
3" PHOTO-EQUATORIAL — with eyepieces for 200x, 171x, 131x, 96x, 67x, 48x **$550**
4" ALTAZIMUTH — with eyepieces for 250x, 214x, 167x, 120x, 83x, 60x **$465**
4" EQUATORIAL — with eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x **$785**
4" PHOTO-EQUATORIAL — with eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x **$890**
4" EQUATORIAL — with clock drive, Model 160V, eyepieces as above **$985**
4" EQUATORIAL — with clock drive and metal pier, Model 166V, eyepieces as above **$1075**
4" PHOTO-EQUATORIAL — with clock drive and Astro-camera, with eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x, 25x **$1175**
4" PHOTO-EQUATORIAL — with clock drive, pier, Astro-camera, eyepieces for 375x, 300x, 250x, 214x, 167x, 120x, 83x, 60x, 38x, 25x **$1280**
5" PHOTO-EQUATORIAL — with clock drive, tripod or pier, viewfinder, Astro-camera Model 220, with eyepieces for 500x, 400x, 333x, 286x, 222x, 160x, 111x, 80x, 50x, 33x **$2275** (with tripod)
6" EQUATORIAL — with clock drive, pier, 2.4" view finder, with eyepieces for 625x, 500x, 416x, 357x, 277x, 200x, 138x, 100x, 62x, 42x **$5125**
6" PHOTO-EQUATORIAL — as above but with 4" guide telescope, illuminated diagonal, Unibalance, Astro-camera Model 330 **$5660**
6" PHOTO-EQUATORIAL — as above with addition of 3" Astrographic Camera Model 80 **$6075**

SEE PAGES 182 AND 183 FOR MORE ABOUT UNITRON.

A word to the budget minded: Unitron's popular Easy Payment Plan is the convenient and economical way to buy one of these superb refractors when you don't want to disturb savings, or when you don't have the total cost of the instrument immediately available. Ask us about it. And be sure to get your free copy of Unitron's Catalog and Observer's Guide — must reading for any prospective telescope buyer.

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